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THE PHILIPPINE AGRICULTURIST

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A REPORT ON A RECENT VISIT TO AUSTRALIA [1]

F. M. FRONDA [2]
Of the Department of Animal Husbandry

WITH TWO TEXT FIGURES

By authority of the University of the Philippines, the writer sailed from Manila aboard the *S. S. "Atuta Maru"* on April 8, 1940, for Melbourne, Victoria, Australia, *via* the ports of Davao, Thursday Island, Brisbane, and Sydney. The trip was for the purpose of making observations on the livestock and poultry industries of the Commonwealth of Australia. The boat arrived in Melbourne on April 29. This city was used as the headquarters in Victoria, and side trips were made from it to various farms within a radius of about one hundred and fifty kilometers. The return trip to Sydney, New South Wales, was made overland. The writer left Melbourne by express train, at 6:00 o'clock in the evening of May 10, and arrived in Sydney shortly after 10:00 o'clock the following morning. There he boarded a steamer for Wellington, New Zealand, a few hours later. The return trip was made from Auckland, New Zealand. He left Auckland on May 25 and arrived in Sydney on May 29. While in Sydney, side trips were made to farms in the vicinity. The trip to Brisbane, Queensland, was from Sydney in a motor car, which left on June 12 and arrived in Brisbane on June 15. Brisbane was used as the headquarters in Queensland. The return trip to Manila was made on the *S. S. "Kamo Maru"*, which left Brisbane on July 3 and arrived in Manila on July 18, 1940, after the usual stop-overs at Townsville, Thursday Island, and Davao. The entire trip, therefore, covered a period of 102 days, of which 48 days were spent on the mainland of Australia. The places visited are indicated in the accompanying map (fig. 1).

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[1] General contribution No. 772.

[2] The writer avails himself of the opportunity to express his deep appreciation and gratitude for the many courtesies extended to him both by private individuals and by government officials in the various states visited in Australia.

Area.[3] New South Wales, which was first colonized by "Captain-General and Governor-in-Chief" Arthur Phillip in 1788, is the oldest colony in the entire Australian continent. Colonization spread gradually from it, and later, other colonies were formed. These were consolidated into a Commonwealth, which came into being on January 1, 1901. The Commonwealth of Australia now consists of a total of 2,974,581 square miles (7,704,164.8 sq. km.) of almost flat country, divided into states and territories as follows:

	Thousand sq. km.	*Percentage of total*
New South Wales[a]	804	10.4
Victoria	228	3.0
Queensland	1,737	22.5
South Australia	984	12.8
Western Australia	2,527	32.8
Tasmania	68	0.9
Northern Territory	1,356	17.6
Total	7,704	100.0

[a] Including the Australian capital territory (Canberra) embracing an area of 912 square miles (2,362 sq. km.).

Climate. Of the total area of Australia, nearly forty per cent lies within the tropics, and the rest, within the temperate zone. The climate of Australia may best be described as mild, the country being less subject to extremes of weather than similar regions in other parts of the world. (See tables 1 and 2.) Except in the higher elevations, which may reach somewhat over 7,300 feet (2,225 m.), snow is very seldom seen even in the middle of the winter (June, July, and August). The hottest months are December, January, and February, when temperature as high as 120°F. (48.9°C.) is occasionally encountered, particularly in the interior parts during prolonged droughts. The coldest part of Australia lies in the southeastern part of New South Wales and eastern part of Victoria (see fig. 1) where the temperature seldom reaches above 100°F. (37.8°C.) even during the hottest months of the year. Here, also, occasional readings of slightly below freezing are recorded during winter. A considerable portion of Australia included in the western portion of New South Wales, southwestern part of Queensland, and the greater part of Western Australia is very dry with an annual rainfall of less than

[3] WILSON, ROLAND C. 1939. Official yearbook of the Commonwealth of Australia, No. 32, xxxii + 990 p. Canberra, Australia: L. F. Johnston, Commonwealth Government Printer.

The figures given in this report were taken largely from this yearbook.

ten inches (254 mm.). Heavy, useful rains are experienced in the southern and eastern parts, which are also the most productive and most populated regions of Australia. The northeast coast of Queensland is the only part of Australia that is visited by hurricanes, and then not often. The rest of Australia is ordinarily calm (fig. 1).

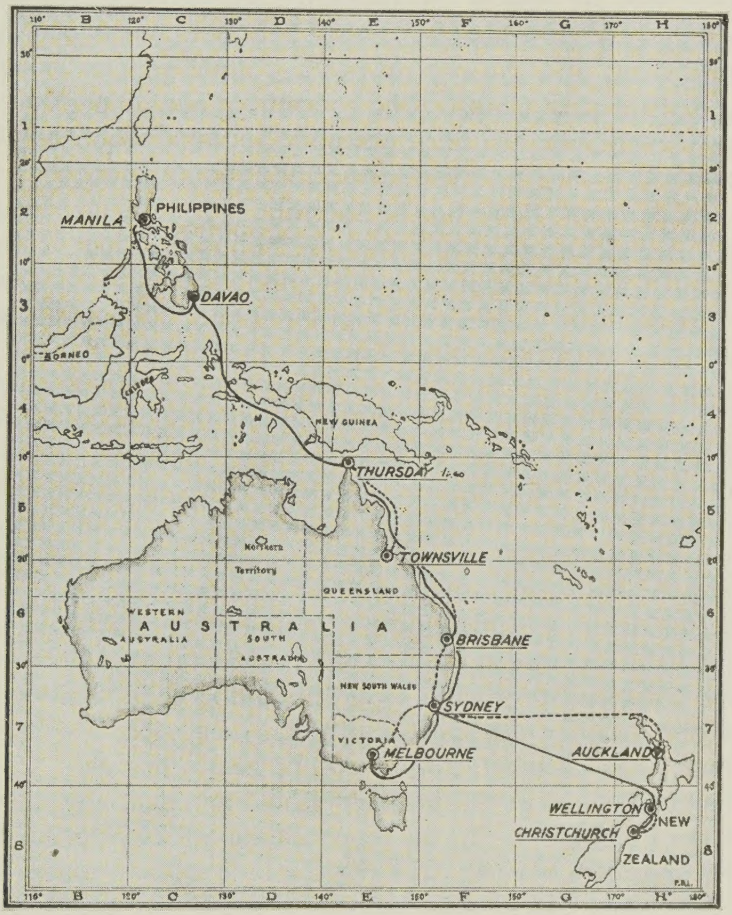

Fig. 1.—Itinerary on trip to Australia.

Population. The latest available census report (June 30, 1938) gives the total population of Australia as 6,894,847, exclusive of the full-blooded aboriginals, of which there is only a very insignificant number, 51,379. The non-aboriginal population of Australia is fundamentally of British stock. These people have the essential char-

acteristics of their British ancestors, "with perhaps some accentuation of the desire for freedom from restraint." About ninety per cent of the entire population are Australian born. The Church of England is the leading church, followed by the Roman Catholic. Many other churches are represented, and of these the Presbyterian and the Methodist are outstanding.

About fifty per cent of the aboriginal population of Australia is still nomadic. A considerable number live in camps supervised by the government, and the rest have some kind of employment on ranches and in other places. The aboriginals are of medium build. They have curly hair and dark chocolate brown skin. The bulk of these aboriginals may now be found in Western Australia.

School system. Education in Australia is free, secular, and compulsory. A child may enter a free kindergarten school at the age of three; and at the age of seven, he must enter a primary school, either a government owned or a registered one. Education is compulsory up to the age of fourteen years. For those living far away, that is, outside the school areas, schooling is by correspondence, but those living within the prescribed areas must be in school when it is in session. Absences must be satisfactorily explained, or the pupil will have to pay a heavy penalty. The child passes through the different primary classes known as Standards I, II, III, and IV, after which he goes to the intermediate school. Should a pupil desire to proceed to higher education, he can sit for the university entrance examination after finishing the three years of post primary school. If he passes the examination, he must remain in school for another year and do satisfactory work to entitle him to earn what is known as a Higher Leaving Certificate. He can then enter a college, and after four years of satisfactory work, he gets a degree.

The curriculum in the primary school is essentially similar to that of the Philippines. In the intermediate schools, the curriculum is richer and more varied. The regular intermediate course is generally two years, but in some schools, a third year course is available. The many subjects that are given are grouped in courses termed professional-industrial, agricultural, art, home-life, etc., according to the composition of the curriculum. There is a wide range of alternative courses for students to choose from.

One of the features of the health service in schools, in addition to the medical and dental inspection of all school children, is the milk-in-school scheme which provides daily a half pint of free milk for

children. The consumption of this milk is entirely voluntary. A survey made not long ago showed that only about eighty-five per cent of the school children accept the milk. In remote places where facilities for pasteurization are not available, free milk is supplied for cocoa making. For this purpose, either whole milk or malted milk powders are issued.

Industries. Australia is primarily a livestock country. During the ten year period from 1928-29 to 1937-38, 58.7 per cent of all Australia's exports were derived from her pastoral, dairy, and farmyard industries. Agricultural products contributed 24.7 per cent of the total exports of the country during the same period. The other major industries are mining, manufacturing, forestry, and fishery.

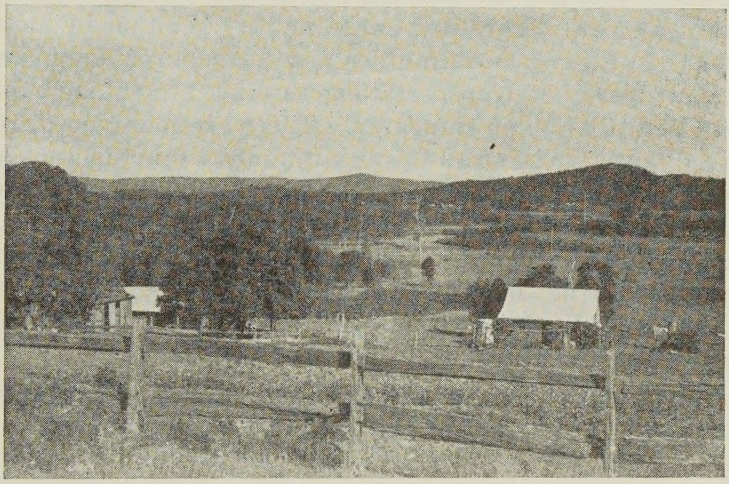

Fig. 2.—A typical farm scene in Australia.

Of the total exports of Australia, primary products represented 95.8 per cent (table 3).

Of the total area of Australia, only 21,951,731 acres (8,883,744 ha.), or about 0.01 per cent, were under crop in 1937-38 (fig. 2). The principal crop is wheat. It is grown in all states, occupying 62.6 per cent of the total area under cultivation. The other important crops are oats, maize, barley, hay, and green forage. Sugar cane is grown mostly in Queensland and a negligible amount in the northern part of New South Wales. Australia produces more sugar than she can consume locally, and she takes pride in the fact that she is the only country in the world that produces sugar by white labor. Rice is also grown in the irrigated portions of New South Wales where

it was first grown on a commercial scale only in 1924-25. Rice growing has made such rapid progress that now the production exceeds the annual requirements of the country. Australia produces both tropical and temperate fruits. The tropical fruits include pineapple, papaya, mango, banana, guava, and custard apple; the temperate, oranges, apples, grapes, peaches, plums, and apricots. Tobacco growing and the cultivation of cotton are Australia's most promising minor industries.

Other observations. Like other peoples, the Australians have their faults, but lack of courtesy to a visitor is certainly not one of them. This, in part, makes travelling in Australia a pleasure. In addition to the fact that the people are very kind, courteous, and helpful, each state has an efficient tourist bureau with branches in the different cities. Travelling in the country is either by motor car or by rail. In the big modern cities and the suburbs, tramways are the cheapest means of transportation, as taxis are rather expensive compared with Philippine standards. There are many good, reasonably priced hotels; even small towns with only a few thousand people are provided with fairly good ones. The Australian is a lover of sports and outdoor life. One may see many people going to the country for camping and outings during week-ends. The roads are excellent, except far out in the country where travel is not so heavy as nearer the city. In those places, the roads are not much different from our macadamized roads in the Philippines.

A Filipino travelling for the first time in Australia may find it rather difficult to understand the monetary system of the country. After a while, however, he will be able to determine the equivalent of his United States dollars and cents in Australian pounds and shillings. At the time of this visit, an Australian pound, written £1/-/- (Aust.) to distinguish it from the pound sterling of England,[4] was worth $3.2484 (U. S.) or approximately ₱6.50 (Philippine). Under normal conditions, £1/-/- (Aust.) is worth a little less than ₱10.

SUMMARY

1. Australia is a relatively young country, having been first colonized in 1788.

2. The country is almost flat and has a mild climate.

3. A considerable portion of Australia is very dry with only about 254 mm. of rainfall a year.

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[4] £1/–/– (sterling) is equivalent to £1/5/– (Aust.)

4. The country is very much under-populated compared with the Philippines and the other Pacific countries.

5. Education in Australia is free, secular, and compulsory. A child must be in school up to the age of fourteen years.

6. Before a student can be admitted to the university in Australia, he must first pass the university entrance examinations.

7. Australia is primarily a livestock country.

8. During the ten year period from 1928-1929 to 1937-1938, 58.7 per cent of all Australia's exports were derived from her pastoral, dairy, and farmyard industries. Agricultural products contributed only 24.7 per cent.

TABLE 1

Mean temperatures in the different cities visited in Australia compared with those of Manila

MONTH	MELBOURNE	SYDNEY	BRISBANE	MANILA
	°C.	°C.	°C.	°C.
January	19.7	22.0	25.1	24.5
February	19.8	21.8	24.8	25.0
March	18.2	20.8	23.5	26.3
April	15.2	18.1	21.2	27.8
May	12.1	15.1	18.1	28.2
June	10.2	12.6	15.1	27.7
July	8.3	11.6	14.8	26.8
August	10.5	12.9	15.8	26.9
September	12.3	15.1	18.4	26.6
October	14.3	17.6	21.0	26.3
November	16.3	19.4	22.9	25.6
December	18.3	21.0	24.5	24.9
Average	14.6	17.2	20.4	26.4

TABLE 2

Mean monthly rainfall in the different cities visited in Australia compared with that of Manila

MONTH	MELBOURNE	SYDNEY	BRISBANE	MANILA
	mm.	*mm.*	*mm.*	*mm.*
January	48.3	92.4	162.2	20.6
February	44.5	107.2	160.9	11.6
March	55.4	123.2	142.1	19.4
April	58.2	137.8	95.2	47.7
May	52.8	127.0	71.6	112.6
June	52.8	121.6	67.5	202.1
July	47.7	121.0	56.1	456.7
August	47.7	74.5	49.5	368.6
September	57.3	72.5	50.6	358.2
October	67.9	72.5	65.0	186.0
November	56.5	71.2	96.6	107.8
December	58.8	74.7	123.0	71.3
Total	647.9	1195.6	1140.3	1962.6

TABLE 3

Principal exports of Australia according to origin

	per cent
Primary produce:	
Agriculture	24.7
Pastoral	49.7
Dairy and farmyard	9.0
Mines and quarries	11.3
Forestry and fisheries	1.1
Manufacturing	4.2
Total	100.0

THE INFLUENCE OF FERRIC CHLORIDE AND OF ZINC SULFATE ON THE PRODUCTION OF CITRIC ACID FROM CANE SUGAR SOLUTIONS BY FERMENTATION WITH ASPERGILLUS NIGER[1]

José P. Zaldivar

Earlier observations have shown that the addition of iron and of zinc salts induced more growth and more sporulation of *Aspergillus niger* van Tieghem. Under different sets of conditions, however, strains of the fungus may require different amounts of the salts for optimum growth—hence, the necessity of determining the concentration of these metallic salts which give the highest citric acid yield with the strains of *Aspergillus niger* isolated and cultured in the sugar laboratory of the Department of Agricultural Chemistry, College of Agriculture, University of the Philippines.

Review of literature

Doelger and Prescott (1934) state that the production of citric acid from sugar solutions by fungi and molds was reported as early as 1892 by Wehmer.

Investigations on the optimum conditions and nutritional requirements for the growth and maximum citric-acid-producing capacity of *Aspergillus niger* were made, among others, by Bortels (1927), Roberg (1928), Porges (1932), Quilico and Di Capua (1932), Rossi and Scandellari (1932), Pirschle (1934), Sotnikov (1934), Steinberg (1935), Vasil'ev (1935), Gollmick (1936), and Kauffmann-Cosla and Brull (1937).

Considering the rôle of ferric chloride and of zinc sulfate on the citric-acid-producing capacity of the fungus, Bortels (1927) demonstrated experimentally that iron and zinc are essential for the existence of *Aspergillus niger*. Zinc stimulates growth but inhibits the sporulation of *Aspergillus*. Roberg (1928) worked on the action of iron, zinc, and copper salts on *Aspergilli* and found that *Aspergillus niger, A. fumagatus,* and *A. oryzae* failed to grow in the absence of

[1] Experiment Station contribution, No. 1404 Prepared in the Department of Agricultural Chemistry under the direction of the late Assistant Professor Getulio A. Guanzon.

iron and of zinc salts. Copper stimulated sporulation. Steinberg (1935) also found that iron, zinc, copper, and manganese were essential for normal growth and sporulation of *Aspergillus niger*, and in acid solutions, the ratios of the yield with these metals to those with one of the elements omitted varied with the heavy metal concentration. Gollmick (1936) reported that minute amounts of zinc, iron, and copper increased growth and sporulation of *Aspergillus niger*. Ferric and ferrous iron had equal potency and the so-called "activated" iron compounds had no greater effects. Too much zinc was toxic. Too much iron inhibited the action of zinc on sporulation. The toxic action of cadmium on the fungus was inhibited by iron. Kauffmann-Cosla and Brull (1937) reported that the absence of zinc, iron, and potassium from the culture medium was unfavorable to the growth and metabolism of *Aspergillus niger*. Potassium was necessary for growth from the start; zinc, after forty-eight hours; and iron, after seventy-two hours.

Porges (1932) found that, as a source of nitrogen, sodium nitrate was far superior to ammonium sulfate or ammonium nitrate in citric acid production. He believed that the presence of ferric chloride affected the formation of the acid; the acidity and weight of the fungus reached their maximum when 0.02 gram $FeCl_3$ was added per liter. A distinct toxic effect was noticeable with high concentrations of the iron chloride. He also found that zinc salts gave the most marked effect, increasing the actual yield of citric acid as well as the amount of total acids per unit weight of sugar used. The greatest yield of citric acid was obtained after an incubation period of seven days. Aërating the solution gave no increase in the acid produced. Renewing the spent solution under the hyphal mat gave no increased acid yields.

Quilico and Di Capua (1932), working on the influence of iron on citric acid fermentation, found that the origin of the enzyme is important. Two strains, *S* and *A*, of *Aspergillus niger*, both capable of inducing citric acid fermentation, were allowed to grow on sugar solutions with and without iron. Citric acid production was inhibited by iron in the case of strain *S* and accelerated in the case of strain *A*.

Rossi and Scandellari (1932) found that the action of ferrous sulfate was opposed to that of manganese sulfate; it delayed, unlike that of magnesium sulfate, invertase production. Zinc stimulated production at low concentrations while at higher concentrations production was inhibited.

Sotnikov (1934) reported that the active mycelium, when cultivated on unhopped barley wort diluted with three parts water to which zinc sulfate (0.005 per cent) and ferric chloride (0.002 per cent) had been added, gave a good start to the fungus. The fermenting solution contained 20 per cent sugar. The addition of magnesium nitrate and potassium nitrate (each containing 25 millimols of nitrogen) raised citric acid production from three to twelve times, the rôle of magnesium being even more marked in changed than unchanged solutions. The addition of smaller quantities of nitrogen decreased the acid produced. The addition of 0.3 to 4 per cent magnesium nitrate to the fermentation medium containing 20 per cent sugar set up conditions favorable only for citric acid production and was, therefore, a reliable guide in the selection of active acid producers.

Vasil'ev (1935) stated that citric and gluconic acids are "metabolic products which serve to characterize bio-chemically different strains of *A. niger*." Some strains gave higher yields of citric acid in sugar cultures containing 0.01 per cent zinc sulfate, and others were not affected at all. Molds which produce chiefly citric acid and very little other acids which form soluble calcium salts yielded more citric acid in the presence of zinc sulfate than in its absence. With other strains which did not have great ability to form acid, zinc sulfate affected markedly sugar utilization and respiration. The work of Pirschle (1934) on comparative physiological effects of elements as shown by growth experiments with a pure strain of *A. niger* demonstrated that zinc and cadmium salts stimulated growth only at low, and were toxic at high, concentrations. The decrease in yield of *Aspergillus niger* on sucrose solutions was due almost entirely to the removal of zinc and molybdenum.

Object of the present work

The object of the present work was to determine the influence of different concentrations of ferric chloride and of zinc sulfate on citric-acid production by fermenting cane sugar solutions, under sterile conditions, with three strains of *Aspergillus niger* van Tieghem.

Time and place of the work

The work was performed in the sugar laboratory of the Department of Agricultural Chemistry, College of Agriculture, University of the Philippines, from October, 1936, to October, 1938.

Materials and Methods

The solutions and reagents used in this study were prepared in accordance with standard methods adopted in the Official and Tentative Methods of Analysis of the Association of Official Agricultural Chemists, Fourth Edition (1935). The centrifugal sugar used was a part of the 1937-1938 crop of the U. P. Sugar Mill.

Strains of Aspergillus niger. Three strains of *Aspergillus niger* van Tieghem designated as 4D36, 11D36, and 14D36, isolated by Demeterio (1937)[2], were used in this study. Re-isolations were made eight consecutive times at intervals of eights days with sterile agar media of the following composition:

Agar	20.00 grams
Sucrose	30.00 "
Sodium nitrate	2.23 "
Dipotassium phosphate	1.00 "
Magnesium sulfate	0.23 "
Normal HCl	7.00 ml.
Water to make up to	1.00 liter

The weighed agar was cooked in a beaker. The sodium nitrate, magnesium sulfate, and dipotassium phosphate were each separately dissolved in water and mixed; then enough normal hydrochloric acid was added to prevent the precipitation of phosphates and to lower the pH to approximately 4. The sucrose, agar, and the acidified salts were mixed, and the volume made up to one liter with distilled water. The mixture was filtered, the filtrate put in several test tubes about one-third full, plugged with cotton, and sterilized at fifteen pounds pressure for thirty minutes.

Iron and zinc salts. The following concentrations of ferric chloride and of zinc sulfate were used: 0.1, 0.2, 0.8, 25, 100, and 200 mg. per liter.

Preparation of sugar solution for inoculation. In all the experiments, 18 per cent sugar solution was used. The solution thus prepared was analyzed for sucrose and total reducing sugars. The resulting pH value of the mixture was determined. Titrations were made for acidity resulting from the subsequent addition of hydro-

[2] Demeterio, J. K. 1937. Citric acid fermentation of commercial sugar and final sugar cane molasses on solid media by *Aspergillus niger*. Thesis presented for graduation with the degree of Bachelor of Science in Sugar Technology from the College of Agriculture, 1937. (Unpublished).

chloric acid. The composition of the stock culture solution was as follows:

Sucrose	180.00 grams
Sodium nitrate	2.23 "
Magnesium sulfate	0.23 "
Dipotassium phosphate	1.00 "
Normal HCl	7.00 ml.
Water to make up to	1.00 liter

The above culture solution was the standard medium proposed by Doelger and Prescott (1934) except that $NaNO_3$ was used instead of NH_4NO_3. The stock solution was prepared according to their directions so that each 50 ml. of the stock solution contained the amount of salts required to make up one liter of the standard medium.

Following the method of Doelger and Prescott (1934), fourteen 500-ml. Erlenmeyer flasks were sterilized for the culture media. Under sterile conditions, 125 ml. of the prepared sugar solution and 25 ml. of the salt and acid mixtures were introduced into each of the 500-ml. sterile volumetric flasks. One liter of culture solution required 17 ml. of normal HCl solution to bring the initial pH to approximately 2.00. Since the salt mixture already contained 3.5 ml. of normal HCl, 5 ml. more of this acid were added to each of the volumetric flasks before making up to volume. The flasks were plugged with cotton.

Inoculation of the culture solutions was accomplished with an aluminum rod with one end flattened and shaped like a paddle. The inoculum introduced to the liquid medium was found sufficient to start rapid initial growth and coverage of the fungus. Re-inoculation of the culture solutions was necessary. The cultures were incubated at room temperature (27°–31°C.)

Determination of sucrose and reducing sugars. (*1*) *Sucrose.* The sucrose content of the sugar solution used for fermentation was determined by Walker's *Inversion Method* as described in *"Methods of Chemical Control for Cane Sugar Factories of the Association of Hawaiian Sugar Technologists"* (1931).

The percentage of sucrose was finally calculated with the aid of table 2 of the *Hawaiian Handbook* (1931) using the uncorrected Brix of the solutions and R, obtained from double polarization by Walker's method *b*, for direct polarization.

Reducing sugars. The reducing sugars of the samples were determined in accordance with the methylene blue method for glucose by Lane and Eynon, *Hawaiian Handbook* (1931).

Proper dilutions for invert sugar determinations were made so that from 15 to 50 ml. of the diluted solution were required in the titration of 10 ml. of the standard Soxhlet's solution. The original 125-ml. sugar solution used for fermentation was adjusted so that the sucrose content did not exceed five grams per 100 ml. Final titrations were made after preliminary titrations were conducted to determine the approximate volume required to reach the end point.

The amount of glucose present per 100 ml. of the solution used in the titration was obtained from the modified glucose table of Locsin (*Compilation of Committee Reports for the Fifth Annual Convention of the Philippine Sugar Association, 1937*) based on the volume of the solution required in the titration and its sucrose content per 100 ml. The total glucose content based on the original 125 ml. sugar solution was calculated.

In the determination of glucose in the fermented liquor, the sample was pipetted directly from the 250-ml. extract. The same procedure of dilution as above was followed. The sugars consumed were obtained by subtracting the residual sugars present in the mother liquor after fermentation from the total original sugars, all as invert sugars.

Preparation and inoculation of the sterile mash. The experimental sugar solution and nutrient salts, which had been previously sterilized separately, were mixed and the pH adjusted to 2.0 by addition of normal HCl. One hundred and twenty-five-milliliter portions were transferred into tared 500-ml. Erlenmeyer flasks in which the necessary sterilized solution of either iron or zinc salts had been previously introduced. These flasks were inoculated with spore suspensions of pure cultures of *Aspergillus niger* and allowed to ferment for a period of nine days. After complete fermentation, the weight of the fungus, pH, reducing sugars, total acidity (expressed in ml. of N/10 acid), and citric acid (based on the total and consumed invert sugars) were all determined. Each test was run in duplicate. Five replications were made on the determination of the maximum period of citric acid production. The same number of replications were made on cultures containing iron and zinc salts of different concentrations.

Treatment of the fermented material and separation of the mother liquor. After the fermentation period of nine days, the mother liquor was separated from the fungous mat by pouring the solution into a 250-ml. volumetric flask holding back the fungous mat with an aluminum rod. Hot water was then introduced into the fermenting flask, and the mat expressed so as to remove the rest of the mother liquor which had been absorbed by the mat. The volumetric flask, with its contents, was now allowed to cool to room temperature, and the volume of the solution finally made up to the mark with distilled water. The tared flask with the fungus mat was then placed in the oven and dried for three to four hours at 100°C., then cooled and weighed.

Quantitative determination of citric acid. The determination was done according to the modified method of Bernhauer (Demeterio, 1937).[3] A 50-ml. portion of the mother liquor was used for the determination of citric acid; whenever the fermented mother liquor was turbid, Kieselguhr was used for clarification. The mother liquor, after the addition of Kieselguhr, was thoroughly shaken and then filtered and the filtrate was used for analysis.

Acidity (pH) of the mother liquor. Before inoculation, the initial acidity after the addition of HCl was determined with the aid of a potentiometer with quinhydrone electrode. For the extracted mother liquor, the same procedure of pH determination was followed.

Determination of sucrose and total reducing sugars in the mother liquor. At the end of the fermentation period, the mother liquor was drained from the fermenting flasks into 250-ml. volumetric flasks and diluted to the mark with distilled water. A portion was analyzed for reducing sugars and the sucrose and total reducing sugars determined as described elsewhere in this paper.

RESULTS AND DISCUSSION

The results obtained in this study are summarized in tables 1, 2, and 3. The figures for fungous growths and citric acid yields are averages of five replications.

The individual strains were studied with economy (citric acid based on invert sugars consumed) and efficiency (citric acid based on the initial sugars, as invert) figures as the criteria for their performance. The weights of fungous mats were used only as compli-

[3] Footnote 2.

mentary criteria, viz., in judging the better of two treatments which gave similar figures for economy and efficiency; that which gave a lower yield of mat was superior because the fungus did not utilize an equivalent amount of energy in building up its own body weight.

The different sets in each treatment (four replications) were not run at the same time. In all treatments, however, all sets with the same number were performed at the same time.

Period of incubation adopted

Preliminary tests have shown that there was not much difference between the seven-, nine-, and twelve-day incubation periods in point of economy and efficiency of citric acid production. To give all the strains the same time factor and to use the same incubation period which was found by Demeterio (1937)[4] to be the best for 11D36, and for convenience in the schedule of analysis, a period of nine days was adopted in this work.

Influence of ferric chloride

Strain 4D36. As shown in table 1, the behavior of the fungus, from the standpoint of economy of citric acid production, was rather variable. There were, however, no significant differences between the means. In point of efficiency, the same general trend of results was obtained. No statistically significant differences were found between the values obtained in the experiments and that of the control. Judged from these results, strain 4D36 was unaffected by the addition of ferric chloride at the different concentrations tried.

The fungous growth did not seem to be influenced by the addition of ferric chloride in the culture solution. The weights of the fungous mats were almost the same in the control as in the tests at different concentrations of the salt. The differences were all statistically insignificant.

Strain 11D36. In point of economy, the application of ferric chloride appeared to have no beneficial effect on the performance of the fungus; all values in the tests were practically the same as those in the control, except in the 200-mg. treatment where a slightly higher value (statistically) was obtained. The individual values obtained under this treatment, however, showed a wide range of variation, throwing some doubt on the applicability of this treatment for commercial citric acid fermentations. On the whole, strain 11D36 as a citric acid-producer was not improved by the addition of ferric

[4] Footnote 2

chloride to the culture solution. In point of efficiency, there were no significant differences between the experiments and the control.

The fungous growths at different concentrations of ferric chloride were not very variable. The maximum average weights of 2.76 ± 0.15 and 2.76 ± 0.16 grams were obtained from the 0.1-mg. and 0.8-mg. treatments respectively. These values, however, were not significantly higher than those obtained in the control.

Strain 14D36. In point of economy, ferric chloride had no beneficial effect on the fungus as a citric acid producer. Yields of citric acid, starting with the 0.2-mg. treatment, had a tendency to decrease with increase in concentration of the salt. Like the other strains studied, 14D36 seemed not to be affected by the different $FeCl_3$ concentrations tried.

As regards efficiency, it was observed that the fungus did not respond at all to the additions of ferric chloride. There was a rather apparent tendency for the yields to decrease with an increase in the salt concentration.

The vegetative growth of this strain, like the other two, was not influenced by the different concentrations of ferric salt added to the culture media. The results obtained in the tests were practically the same in all the concentrations used. The differences in the weights of fungous mats from the tests, and those of the control, were insignificant.

From the foregoing results, it may be deduced that all the strains were not influenced by ferric chloride in the different concentrations used.

Influence of zinc sulfate

Strain 4D36. There was no indication of stimulation of the activity of the fungus at all concentrations of the salt (table 2). This is somewhat contradictory to the findings of Bortels (1927), who noted that zinc and iron stimulated the growth of *Aspergillus niger* and that zinc hastened spore formation. It is probable, however, that conditions in the present experiment were not identical with those of Bortels (1927).

With respect to economy of production, the effect of zinc was not demonstrated, for the differences in yield of citric acid between the control and those of the tests were all insignificant. The percentages of citric acid based on the original sugars (efficiency) were practically the same, both in the experiments and in the control.

Strain 11D36. Table 2 also shows that this fungus was not influenced by zinc sulfate in its economy of citric acid production. The indifference of strain 11D36 to zinc sulfate was more markedly noticeable in point of efficiency. The percentages of citric acid based on the original sugars were practically the same. The different concentrations of zinc sulfate had no influence on the amount of fungous mat produced. There was no significant difference between the fungous growth in the control and in the different tests.

Strain 14D36. The economy and efficiency figures as indices of the performance of this strain show that zinc sulfate had a more or less unfavorable effect on the fungus. Percentages of citric acid in the experiments had a tendency to decrease in value with increase in the concentration of zinc sulfate, although the differences were statistically insignificant.

The values obtained on efficiency followed the same downward trend with increasing zinc sulfate concentrations, with the exception of those for the 100- and 200-mg. concentrations. In all cases, the figures for the control somewhat exceeded those of the tests. The differences, however, between the experiments and the control in no case were statistically significant.

An examination of the figures on fungous growths reveals that the weights of mat, which are criteria of the activity of the fungus, were similar both in the tests and in the control.

Comparative efficiencies of the Aspergillus niger strains used

Table 3 gives the comparative citric acid producing capacities of the three strains used as influenced by varying concentrations of ferric chloride.

Table 3 shows that 11D36 was a poor citric acid producer in point of economy, while 4D36 and 14D36 were the same. In point of efficiency, 14D36 was the best, 4D36 next, and 11D36 last, all differences being significant except in the control between 4D36 and 14D36. The fungous growth of 14D36 for the control, however, was less than that of 4D36, a fact which tends to discount the insignificant difference between the efficiencies of the two strains.

In regard to the influence of zinc sulfate on economy and efficiency of citric acid production by the three strains, the differences were all statistically insignificant.

SUMMARY AND CONCLUSIONS

1. The influence of different concentrations (0.1, 0.2, 0.8, 25, 100, 200 mg. per liter) of ferric chloride and of zinc sulfate on citric acid production by *Aspergillus niger* van Tieghem was studied.

2. Pure cultures of strains 4D36, 11D36, and 14D36 of *Aspergillus niger,* isolated and cultured in the sugar laboratory of the Department of Agricultural Chemistry, were employed. A period of nine days incubation was adopted for all the strains.

3. Neither ferric chloride nor zinc sulfate increased or decreased the citric-acid producing capacities of the individual strains.

4. Strain 11D36 was the poorest citric acid yielder, and 14D36 the best among the three strains of *Aspergillus niger* studied. In point of economy of citric acid production, 4D36 was just as good as 14D36; but in point of efficiency, 14D36 was decidedly better. Their differences may be attributed to their inherent characteristics.

LITERATURE CITED

ANON. 1931. Methods of chemical control for cane sugar factories of the Association of Hawaiian Sugar Technologists. 6th revision, 140 p., 11 figs. Honolulu: Advertizer Publishing Co., Ltd.

BORTELS, HERMANN. 1927. The significance of iron, zinc, and copper for microorganisms. Biochem. Z. **182**: 301–358. *Cited in* Chem. Abs. **21**: 2490.

DOELGER, W. P., AND S. C. PRESCOTT. 1934. Citric acid fermentation. Ind. Engin. Chem. **26**: 1142–1149. *Fig. 1–5.*

GOLLMICK, FRIEDERICH. 1936. The influence of zinc, iron, copper and their combinations on the growth of *Aspergillus niger.* Zentr. Bakt. Parasitenk. II. Abt. **93**: 421–442. *Cited in* Chem. Abs. **30**: 4534.

KAUFFMANN-CCSLA, O., AND R. BRULL. 1937. The biological importance of the ions of zinc, iron, and potassium in growth and metabolism. Arch. intern. pharmacodynamie **57**: 188–194. *Cited in* Chem. Abs. **32**: 1736.

PIRSCHLE, KARL. 1934. Comparative investigations on the physiological effect of the elements as shown by growth experiments with *Aspergillus niger* (Stimulation and toxicity). Plants (Abt. E. Z. Wiss. Biol.) **23**: 177–224. *Cited in* Chem. Abs. **29**: 2201.

PORGES, NANDOR. 1932. Citric acid production by *Aspergillus niger.* Amer. Jour. Bot. **19**: 559–567.

QUILICO, A., AND A. DI CAPUA. 1932. The influence of iron on the citric acid fermentation of *Aspergillus niger.* Giorn. chim. ind. applicata **14**: 289–293. *Cited in* Chem. Abs. **26**: 5987.

ROBERG, MAX. 1928. The action of iron, zinc, and copper salts on *Aspergilli.* Centr. Bakt. Parasitenk. II Abt. **74**: 333–370. *Cited in* Chem. Abs. **22**: 3678.

ROSSI, G., AND G. SCANDELLARI. 1932. The influence of some salts on the invertase production in *Aspergillus niger*. Biochim. terap. sper. **19**: 157–161. *Cited in* Chem. Abs. **26**: 5123.

SOTNIKOV, E. I. 1934. II. Production of citric acid by *Aspergillus niger* in changed solution. Compt. red. acad. sci. U. S. S. R. **3**: 279–281. *Cited in* Chem. Abs. **28**: 6760.

STEINBERG, R. A. 1935. Some effects of heavy metals essential for the nutrition of *Aspergillus niger* upon its growth. Amer. Jour. Bot. **23**: 227–231.

THORPE, EDWARD. 1919. A dictionary of applied chemistry. The citric acid fermentation. **2**: *viii* + 786 p., illus. London: Longmans' Green, and Co.

VASIL'EV, G. 1935. Biochemical characterization of certain strains of *Aspergillus niger* on the basis of acid-forming capacity. Biochem. Z. **278**: 226–234. *Cited in* Chem. Abs. **29**: 8056.

TABLE 1

The influence of ferric chloride on the production of citric acid by Aspergillus niger strains in an 18 per cent sugar solution

STRAIN	FERRIC CHLORIDE PER LITER	FUNGOUS GROWTH	CITRIC ACID BASED ON INVERT SUGARS CONSUMED	CITRIC ACID BASED ON TOTAL ORIGINAL SUGARS (AS INVERT)	pH RANGE [a]
	mgm.	*grams*	*per cent*	*per cent*	
4D36	Control	3.12 ± 0.16	11.60 ± 1.04	3.49 ± 0.24	2.8–3.5
	0.1	3.13 ± 0.14	12.00 ± 0.90	3.60 ± 0.30	2.9–3.6
	0.2	3.21 ± 0.17	10.83 ± 1.16	3.35 ± 0.34	2.8–3.9
	0.8	3.17 ± 0.23	12.93 ± 1.26	3.96 ± 0.35	2.8–3.8
	25.0	2.96 ± 0.25	11.04 ± 0.45	3.16 ± 0.18	2.8–3.5
	100.0	3.01 ± 0.27	10.15 ± 0.53	3.03 ± 0.19	2.9–3.6
	200.0	3.07 ± 0.29	9.04 ± 1.08	2.73 ± 0.22	2.9–3.7
11D36	Control	2.65 ± 0.19	1.02 ± 0.13	0.34 ± 0.03	2.9–4.4
	0.1	2.76 ± 0.15	1.19 ± 0.16	0.40 ± 0.04	3.0–4.1
	0.2	2.68 ± 0.20	1.33 ± 0.18	0.43 ± 0.04	3.0–4.0
	0.8	2.76 ± 0.16	1.10 ± 0.15	0.36 ± 0.03	3.0–4.2
	25.0	2.56 ± 0.21	1.30 ± 0.17	0.40 ± 0.04	3.1–4.2
	100.0	2.66 ± 0.07	1.48 ± 0.20	0.43 ± 0.04	3.0–4.1
	200.0	2.50 ± 0.08	1.65 ± 0.14	0.44 ± 0.04	3.0–4.2
14D36	Control	2.17 ± 0.12	13.31 ± 1.95	6.21 ± 1.16	2.9–3.8
	0.1	2.23 ± 0.09	15.59 ± 1.93	7.02 ± 1.01	3.0–3.7
	0.2	2.30 ± 0.10	16.48 ± 1.46	6.83 ± 0.84	2.8–3.6
	0.8	2.37 ± 0.15	15.75 ± 1.30	6.60 ± 0.68	3.0–3.4
	25.0	2.21 ± 0.10	13.58 ± 1.21	5.57 ± 0.74	2.9–3.3
	100.0	2.26 ± 0.12	13.85 ± 1.16	5.51 ± 0.60	3.0–3.4
	200.0	2.25 ± 0.11	11.44 ± 0.74	4.60 ± 0.54	2.9–3.3

[a] The pH values of the different sets were determined after the incubation period of 9 days. The initial pH and sugar contents of each number in each set were the same in all the runs with the different strains.

TABLE 2

The influence of zinc sulfate on the production of citric acid by Aspergillus niger strains in an 18 per cent sugar solution

STRAIN	ZINC SULFATE PER LITER	FUNGOUS GROWTH	CITRIC ACID BASED ON INVERT SUGARS CONSUMED	CITRIC ACID BASED ON TOTAL ORIGINAL SUGARS (AS INVERT)	pH RANGE [a]
	mgm.	*grams*	*per cent*	*per cent*	
4D36	Control	2.92 ± 0.48	10.41 ± 1.44	2.90 ± 0.44	3.0–4.3
	0.1	2.84 ± 0.36	11.52 ± 1.22	2.91 ± 0.30	2.9–4.3
	0.2	2.94 ± 0.39	10.73 ± 1.35	3.00 ± 0.41	2.9–4.3
	0.8	3.01 ± 0.41	11.73 ± 1.69	3.15 ± 0.46	2.7–3.7
	25.0	2.68 ± 0.37	11.21 ± 1.51	2.79 ± 0.30	2.5–4.2
	100.0	2.62 ± 0.34	11.39 ± 1.54	2.81 ± 0.34	2.6–3.9
	200.0	2.51 ± 0.34	10.89 ± 0.74	2.82 ± 0.36	2.7–3.8
11D36	Control	2.94 ± 0.07	5.83 ± 1.39	2.25 ± 0.64	2.5–4.4
	0.1	3.07 ± 0.25	5.94 ± 1.39	2.40 ± 0.67	2.6–4.5
	0.2	2.81 ± 0.32	5.08 ± 1.12	2.11 ± 0.58	2.7–3.8
	0.8	2.90 ± 0.36	5.59 ± 1.08	2.43 ± 0.64	2.7–4.4
	25.0	2.87 ± 0.25	6.26 ± 1.63	2.50 ± 0.73	2.3–4.0
	100.0	2.77 ± 0.27	6.23 ± 1.55	2.57 ± 0.67	2.4–3.9
	200.0	2.95 ± 0.36	5.99 ± 1.71	2.51 ± 0.82	2.2–4.0
14D36	Control	2.78 ± 0.14	13.60 ± 2.05	4.87 ± 0.56	2.7–4.0
	0.1	2.88 ± 0.12	13.01 ± 2.26	4.66 ± 0.69	2.7–4.3
	0.2	2.99 ± 0.10	12.71 ± 2.30	4.56 ± 0.71	2.7–4.3
	0.8	2.94 ± 0.12	12.35 ± 2.31	4.43 ± 0.70	2.7–4.5
	25.0	3.04 ± 0.11	10.17 ± 2.26	3.76 ± 0.77	2.7–4.4
	100.0	2.88 ± 0.18	10.04 ± 2.58	3.92 ± 0.70	2.6–4.7
	200.0	2.91 ± 0.10	9.86 ± 2.54	4.18 ± 1.06	2.6–4.5

[a] The pH values of the different sets were determined after the incubation period of 9 days. The initial pH and sugar contents of each number in each set were the same in all the runs with the different strains.

TABLE 3

Comparative citric acid producing capacities of the different Aspergillus niger strains in the presence of varying amounts of ferric chloride

SALT CONCENTRATION PER LITER	CITRIC ACID BASED ON INVERT SUGARS CONSUMED		
	4D36 vs 11D36	4D36 vs 14D36	11D36 vs 14D36
mgm.	*per cent*	*per cent*	*per cent*
Control	11.60 ± 1.04 — 1.02 ± 0.13	11.60 ± 1.04 — 13.31 ± 1.95	1.02 ± 0.13 — 13.31 ± 1.95
	10.58 ± 1.05 (VS)	— 1.71 ± 2.21 (I)	— 12.29 ± 1.95 (VS)
0.1	12.00 ± 0.90 — 1.19 ± 0.16	12.00 ± 0.90 — 15.59 ± 1.93	1.19 ± 0.16 — 15.59 ± 1.93
	10.81 ± 0.91 (VS)	— 3.59 ± 2.13 (I)	— 14.40 ± 1.94 (VS)
0.2	10.83 ± 1.16 — 1.33 ± 0.18	10.83 ± 1.16 — 16.48 ± 1.46	1.33 ± 0.18 — 16.48 ± 1.46
	9.50 ± 1.17 (VS)	— 5.65 ± 1.86 (I)	— 15.15 ± 1.47 (VS)
0.8	12.93 ± 1.26 — 1.10 ± 0.15	12.93 ± 1.26 — 15.75 ± 1.30	1.10 ± 0.15 — 15.75 ± 1.30
	11.83 ± 1.27 (VS)	— 2.82 ± 1.81 (I)	— 14.65 ± 1.31 (VS)
25.0	11.04 ± 0.45 — 1.30 ± 0.17	11.04 ± 0.45 — 13.58 ± 1.21	1.30 ± 0.17 — 13.58 ± 1.21
	9.74 ± 0.48 (VS)	— 2.54 ± 1.29 (I)	— 12.28 ± 1.22 (VS)
100.0	10.15 ± 0.53 — 1.48 ± 0.20	10.15 ± 0.53 — 13.85 ± 1.16	1.48 ± 0.20 — 13.85 ± 1.16
	8.67 ± 0.57 (VS)	— 3.70 ± 1.28 (I)	— 12.37 ± 1.18 (VS)
200.0	9.04 ± 1.08 — 1.65 ± 0.14	9.04 ± 1.08 — 11.44 ± 0.74	1.65 ± 0.14 — 11.44 ± 0.74
	7.39 ± 1.09 (VS)	— 2.40 ± 1.31 (I)	— 9.79 ± 0.75 (VS)

(VS)—Very significant difference.
(I)—Insignificant difference.
(S)—Significant difference.

TABLE 3 (continued)

SALT CONCENTRATION PER LITER	CITRIC ACID BASED ON TOTAL INVERT SUGARS		
	4D36 vs 11D36	4D36 vs 14D36	11D36 vs 14D36
mgm.	*per cent*	*per cent*	*per cent*
Control	3.49 ± 0.24 — 0.34 ± 0.03	3.49 ± 0.24 — 6.21 ± 1.16	0.34 ± 0.03 — 6.21 ± 1.16
	3.15 ± 0.24 (VS)	— 2.72 ± 1.18 (I)	— 5.87 ± 1.16 (S)
0.1	3.60 ± 0.30 — 0.40 ± 0.04	3.60 ± 0.30 — 7.02 ± 1.01	0.40 ± 0.04 — 7.02 ± 1.01
	3.20 ± 0.30 (VS)	— 3.42 ± 1.05 (S)	— 6.62 ± 1.01 (VS)
0.2	3.35 ± 0.34 — 0.43 ± 0.04	3.35 ± 0.34 — 6.83 ± 0.84	0.43 ± 0.04 — 6.83 ± 0.84
	2.92 ± 0.34 (VS)	— 3.48 ± 0.91 (S)	— 6.40 ± 0.84 (VS)
0.8	3.96 ± 0.35 — 0.36 ± 0.03	3.96 ± 0.35 — 6.60 ± 0.68	0.36 ± 0.03 — 6.60 ± 0.60
	3.60 ± 0.35 (VS)	— 2.64 ± 0.76 (S)	— 6.24 ± 0.60 (VS)
25.0	3.16 ± 0.18 — 0.40 ± 0.04	3.16 ± 0.18 — 5.57 ± 0.74	0.40 ± 0.04 — 5.57 ± 0.74
	2.76 ± 0.18 (VS)	— 2.41 ± 0.76 (S)	— 5.17 ± 0.74 (VS)
100.0	3.03 ± 0.19 — 0.43 ± 0.04	3.03 ± 0.19 — 5.51 ± 0.60	0.43 ± 0.04 — 5.51 ± 0.60
	2.60 ± 0.19 (VS)	— 2.48 ± 0.63 (S)	— 5.08 ± 0.60 (VS)
200.0	2.73 ± 0.22 — 0.44 ± 0.04	2.73 ± 0.22 — 4.60 ± 0.54	0.44 ± 0.04 — 4.60 ± 0.54
	2.29 ± 0.22 (VS)	— 1.87 ± 0.58 (S)	— 4.16 ± 0.54 (VS)

(VS)—Very significant difference.
(I)—Insignificant difference.
(S)—Significant difference.

A STUDY ON THE PREPARATION OF COMPOST FROM RICE STRAW[1]

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WITH EIGHT TEXT FIGURES

The preparation of compost from rice straw is a farm practice which should be given due attention particularly in the Philippines where straw abounds. This farm practice is an integral part of a sound soil management. The work of Sarao (1918) gives information on the value of Philippine composts and that of Venezuela[2], on the effects of some chemicals on the preparation of synthetic farm yard manure. Because of the several advantages derived from the use of compost over that of undecomposed materials, foreign workers have standardized techniques for its preparation. Acharya and Subrahmanian (1939) report the "Adco" process of Richards (1921), the "Indore" of Howard and Wad (1931), the "activated compost" of Fowler (1934), and the "hot fermentation" of Krantz (1925). The findings of Ayyar (1923), Hutchinson and Richards (1925), Albretch (1927), Halverson and Torgerson (1927), Brown and Smith (1929), and Orchard (1939) are valuable guides in the preparation of Philippine compost.

The objects of the present study were to find: (*a*) the rate of composting of rice straw alone, (*b*) the effect of soil, wood ash, carabao dung, or horse dung on the rate of composting of straw, (*c*) the effect of commercial fertilizers on the rate of composting of straw alone, straw alternated with soil, wood ash, carabao dung, or horse dung; and (*d*) the fertilizing value of the prepared composts using pe-tsai [*Brassica pekinensis* Rupr. (Kraus, 1940)] as the indicator of fertility.

MATERIALS AND METHODS

Kerosene cans. Three hundred and twenty kerosene cans (19 liters capacity) with both inner and outer sides coated with coal tar were used as containers.

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[1] Experiment Station contribution No. 1405.

[2] VENEZUELA, FAVIO M. Studies on the preparation of synthetic farm yard manure. Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture, 1930. (Unpublished).

Rice straw. More than 320 kilograms of rice straw (sun-dried) of the Guinangang rice variety were used. This was taken from farms at the junction of Los Baños and Bay, Laguna, from April to May, 1939. It was chopped into small pieces and thoroughly mixed before composting in order to obtain a composite material. It contained 0.72 per cent N, 0.37 per cent P_2O_5, 1.09 per cent K_2O, and 0.30 per cent CaO.

Manures. Fresh carabao and horse dung from the Department of Animal Husbandry, College of Agriculture, was used. The carabao dung contained 1.23 per cent N, 1.65 per cent P_2O_5, 1.02 per cent K_2O, and 0.40 per cent CaO, whereas the horse dung contained 0.97 per cent N, 1.40 per cent P_2O_5, 1.16 per cent K_2O, and 0.80 per cent CaO.

Fig. 1.—The typical relative appearance and growth of pe-tsai (*Brassica pekinensis* Rupr.) in a mixture of an equal weight of soil and composts and in soil alone. (*1*) in 1.5 kilograms soil mixed with 1.5 kilograms of composted straw alone, (*2*) in 1.5 kilograms of soil mixed with 1.5 kilograms of composted straw alternated with soil, (*3*) in 1.5 kilograms of soil mixed with 1.5 kilograms of composted alternated with wood ash, (*4*) in 1.5 kilograms of soil mixed with 1.5 kilograms of composted straw alternated with 1.5 kilograms of carabao dung, (*5*) in 1.5 kilograms of soil mixed with 1.5 kilograms of composted straw alternated with horse dung, (*6*) in 3 kilograms of soil alone (control). Photograph by the Photographic Division, College of Agriculture.

Wood ash. Wood ash obtained from the Department of Agricultural Chemistry, during the summer milling season of 1939 was used. It was light grey, fine in texture, and contained 0.66 per cent P_2O_5, 1.19 per K_2O, and 9.75 per cent CaO.

Soil. Clay loam of the Ibaan series taken from lots behind the Soils Building, and containing 0.16 per cent N, 0.21 per cent P_2O_5, 0.17 per cent K_2O, and 0.40 per cent CaO was used in this study.

Fertilizers. Ammonium sulfate containing 20.6 per cent N, superphosphate, 18-20 per cent P_2O_5, potassium chloride, 48-50 per cent K_2O, and hydrated calcium oxide were also used.

Preparation of the compost. Five series of composting materials were employed. The first series was straw alone previously soaked in water; the second, straw previously soaked in water and alternated with soil; the third, fourth, and fifth were similar to the second but were alternated with wood ash, carabao dung, and horse dung, respectively. The last four series were prepared by placing at the bottom of the container 400 grams of straw previously soaked in water followed by 500 grams of soil, wood ash, carabao dung, or horse dung, then 400 grams of straw again followed by 500 grams of the materials in the second layer, and finally 200 grams of straw. Each series was carried out in four replications.

The composting materials were compacted as uniformly as possible, and their initial volumes, weights, and temperatures were

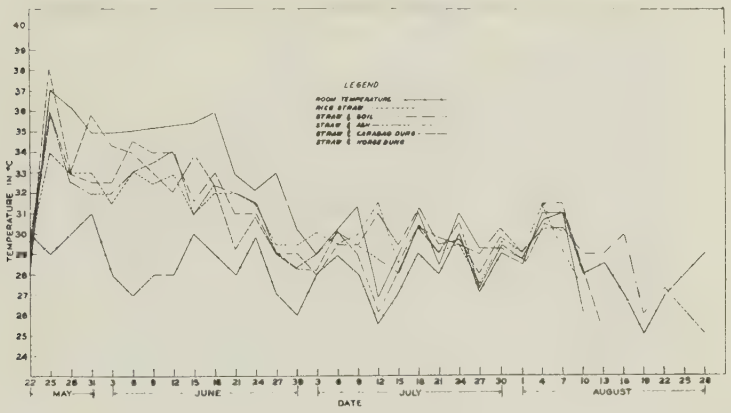
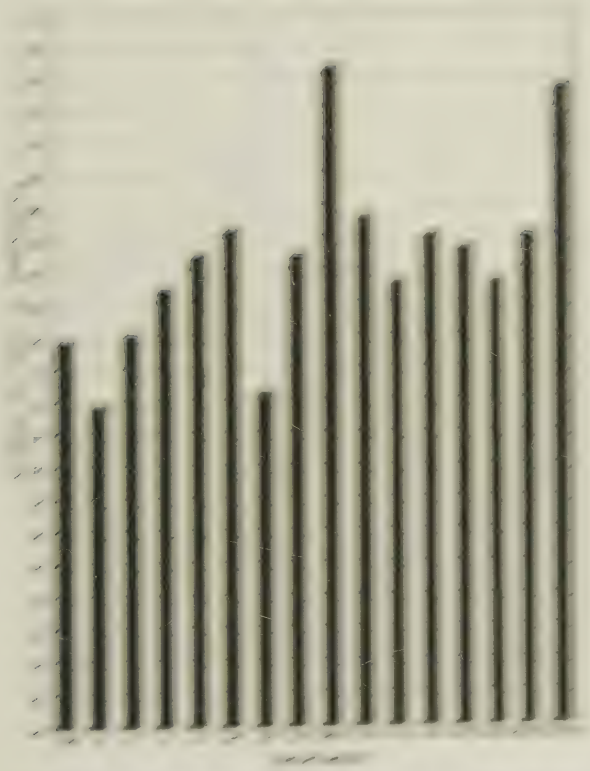


Fig. 2.—The typical change in temperature of the decomposing materials.

noted. They were allowed to incubate in one of the well ventilated buildings of the Department of Soils and turned over from time to time to facilitate aëration. The initial weights were maintained constant by the addition of water as often as necessary, and the volume and temperature changes were observed every three days and every week, respectively.

In addition to these, five other series prepared in a manner similar to the foregoing but with rice straw previously soaked in one-tenth per cent solution of N, P, K, Ca, N-P, N-K, P-K, N-P-K, N-Ca, P-Ca, K-Ca, N-P-Ca, N-K-Ca, P-K-Ca, and N-P-K-Ca were studied in accordance with the technique employed in composting the first five series.



composts was carried out in four replications. Necessary cultivation, weeding, and watering was given each pot. Two months after being planted, the seedlings were harvested, and the fresh weights were taken.

Observations on the growth of pe-tsai plant. In general the plants grown in an equal amount of compost and soil were more luxuriant than those grown in soil alone, control. Those planted in

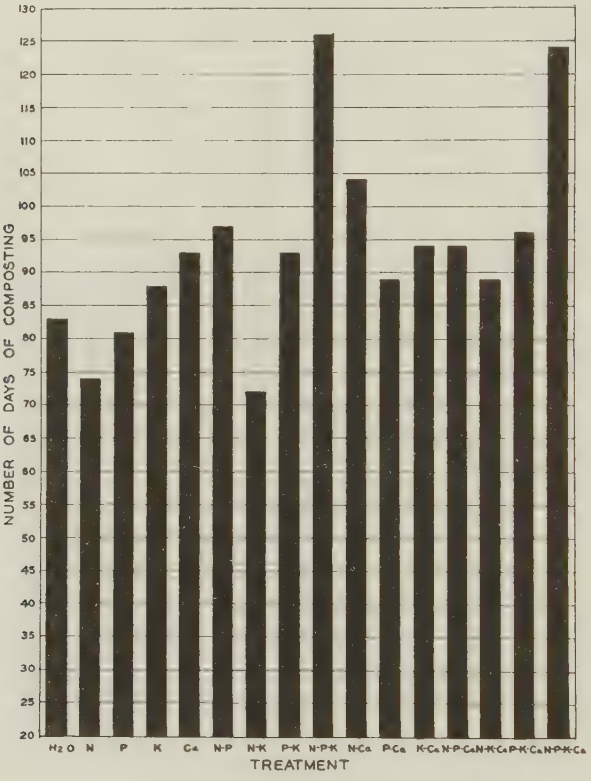


Fig. 5.—The relative rate of decomposition of straw previously soaked in fifteen different fertilizer solutions and alternated with soil.

straw-ash compost and soil, however, were smaller than the control (fig. 1). When rice straw previously soaked in one-tenth per cent solution of N–K, N–P, Ca, N–Ca, P–K–Ca, and N–P–K–Ca was used with ash in composting, the composts when mixed with soil failed to improve the seedlings. Such composts apparently imparted to the soil properties incompatible with the requirement of

pe-tsai. The rest of the solutions produced straw-ash composts of less toxicity since their addition to the soil allowed the plant to grow, although not so vigorously as the control.

DISCUSSION OF RESULTS

The results of the study are given in tables 1 and 2. The data in table 1 are depicted in figures 3, 4, 5, 6, and 7.

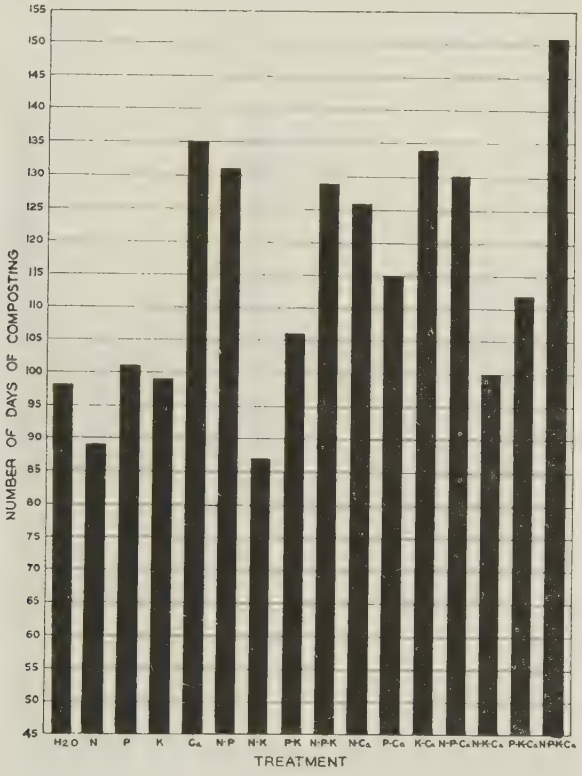


Fig. 6.—The relative rate of decomposition of straw previously soaked in fifteen different fertilizer solutions and alternated with wood ash.

With straw alone as control, table 1, water treatment, shows that either soil or wood ash prolonged the rate of composting of straw. Carabao dung did not affect the rate of metamorphosis, whereas horse dung accelerated it.

The data in table 1, straw alone series, and figure 4 reveal that rice straw alone treated with N and N-K solution composted earlier than the control, rice straw alone treated with water. This shows

that the soaking of straw in one-tenth per cent solution of N and N–K augmented the activities of the organisms responsible for decomposition. Table 1 and figure 4 also show that the control lost its original texture sooner than the rest of the treatment, indicating that the other fertilizer solutions inhibited the activities of the organisms.

When the effect of the fifteen different fertilizer solutions on the rate of composting of the four other series are compared, table

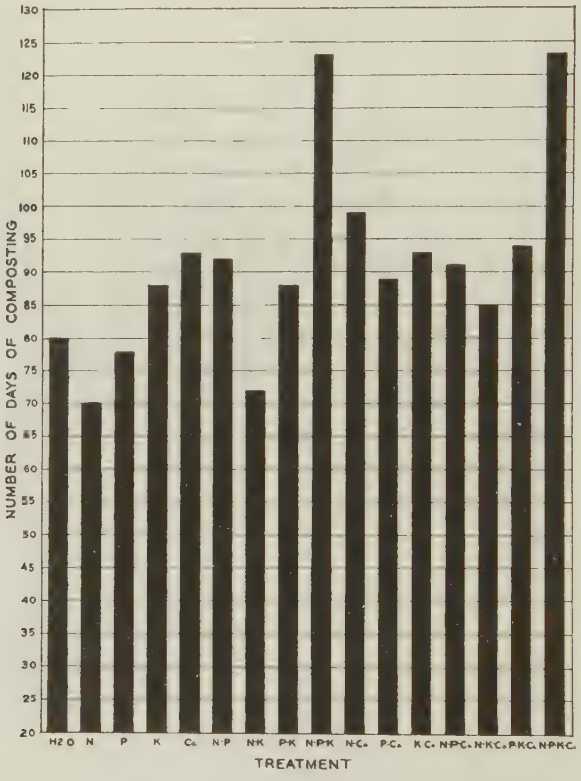


Fig. 7.—The relative rate of decomposition of straw previously soaked in fifteen different fertilizer solutions and alternated with carabao dung.

1 and figure 5 show that N, P, and N-K improved the rate of transformation into compost of the straw-soil series. Therefore, the other fertilizer solutions apparently failed to repress the retarding effect of soil in the composting of straw. The only fertilizer solutions of the straw-ash series, figure 6, which hastened the rate of composting were N and N–K, whereas the rest delayed it. The rate of the

decomposition of the straw-carabao dung series, figure 7, was hastened by N-, P-, and N-K-solution; the rest of the fertilizers lengthened the composting period. With regard to the fertilizers in the straw-horse dung series, figure 8 shows that only N and N-K treatment shortened the composting time, but the others extended it. This may indicate that the accelerating effect of horse dung on the composting of straw was completely checked by the rest of the fertilizers.

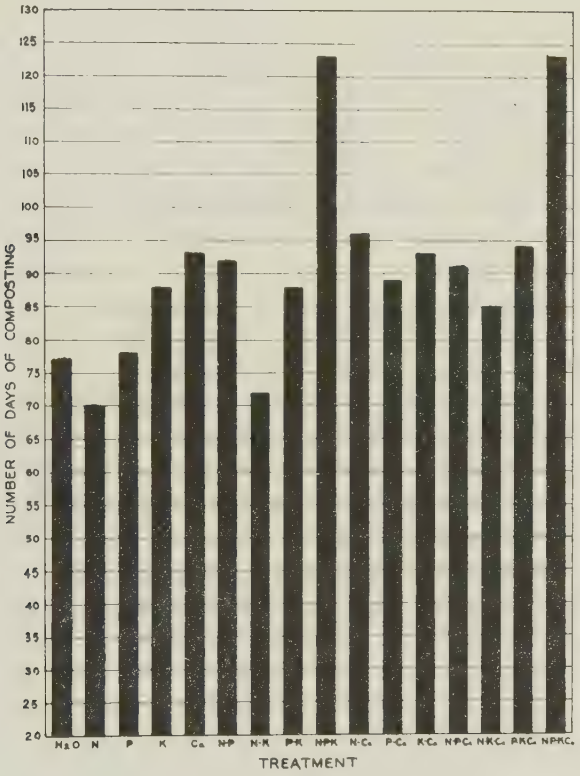


Fig. 8.—The relative rate of decomposition of straw previously soaked in fifteen different fertilizer solutions and alternated with horse dung.

In assessing and evaluating the data in table 2, it is apparent that the pe-tsai plants grown in a mixture of an equal weight of soil and composts, particularly those of straw alone, straw-soil, straw-carabao dung, and straw-horse dung, were in all treatments heavier than the control plants grown in soil alone. Those planted in a mixture of soil and straw-ash compost were in general not very

good. This may be attributed to the high lime content of the ash used and to the caking of the mixture. Venezuela[3] reported that mustard plants failed to grow when planted in compost previously treated with lime, and Espino and Pantaleon (1933) stated that rice straw, rice straw-ash, or both straw and ash in clay loam soil in pots was harmful to the growth and development of young rice and maize plants.

The plants grown in a mixture of soil and straw-soil compost weighed more than those grown in a mixture of soil and only straw compost (table 2). Table 2 reveals further that the plants harvested from soil and straw-carabao dung as well as those from soil and straw-horse dung compost were heavier than those from either straw alone or straw-soil series. These findings indicate that the straw-soil, straw-carabao dung, and straw-horse dung series produced composts of higher fertilizing value than straw alone, and that the straw-carabao dung and horse dung series were better than the straw-soil compost.

SUMMARY AND CONCLUSIONS

1. Under controlled conditions, composts similar to a well rotted stable manure were produced from rice straw alone previously treated either with water or one-tenth per cent fertilizer solutions and also from its mixture with soil, wood ash, carabao dung, or horse dung. The composted material was dark and soft to the touch.

2. Straw alone moistened with water composted in 80 days. The addition of soil and wood ash separately delayed the rate of decomposition. Carabao dung did not have any effect on the process of decomposition. On the other hand, horse dung accelerated the rate of decomposition.

3. The rate of decomposition of rice straw alone and rice straw alternated with soil, wood ash, carabao dung, and horse dung was accelerated by N- and N-K- solution. Phosphatic solution showed a similar effect in the transformation of rice straw alternated with soil and carabao dung into compost. The rest of the fertilizer solutions reduced the rate of decomposition.

4. The plants grown in a mixture of an equal weight of soil and composts, namely, straw, straw-soil, straw-carabao dung, and straw-horse dung, were darker, more luxuriant, and heavier than those grown in the control, soil alone. The plants in a mixture of

[3] Footnote 2.

soil and straw-ash composts failed to grow in most cases. Those that survived were no better than the control.

5. The heaviest plants were those harvested from soil with straw-carabao dung and straw-horse dung compost. This shows that the compost produced from straw alone was not so good as that from straw mixed with carabao dung or horse dung, indicating that the presence of either carabao dung or horse dung is essential for increasing the fertilizing value of straw compost.

LITERATURE CITED

ACHARYA, C. M., AND V. SUBRAHMANIAN. 1939. The hot fermentation process for composting town refuse and other waste material. Indian Jour. Agric. Sci. **9**: 741-744.

ALBRETCH, W. A. 1927. Artificial manure production on the farm. Missouri Agric. Exper. Sta. Bull. 258:1-20. *Fig. 1-11.*

ANONYMOUS. 1935. Official and tentative methods of analysis of official agricultural chemists. 3rd ed., xvii + 593 p. Washington, D. C: Assoc. Agric. Chem.

AYYAR, K. S. V. 1923. Note on the making of artificial farmyard manure. (Madras Agricultural Dept. Yearbook **1923**, 21-25.) *Cited in* U. S. Exper. Sta. Rec. **54**: 421.

BROWN, P. E., AND F. B. SMITH, 1929. The production of artificial manure from oats straw under controlled conditions. Jour. Amer. Soc. Agron. **21**: 310-322.

ESPINO, R. B., AND F. T. PANTALEON. 1923. Harmful effects upon young rice and maize plants of rice straw when added to clay loam soil in pots. The Philippine Agriculturist **12**: 534-556.

HALVERSON, W. V., AND E. F. TORGERSON. 1927. Production of artificial farm yard manure by fermenting straw. Jour. Amer. Soc. Agron. **19**: 577-582.

HUTCHINSON, H. B., AND E. H. RICHARDS. 1925. Artificial farm yard manure. Trop. Agric. **64**: 24-30.

KRAUS, JAMES E. 1940. Chinese cabbage varieties, their classification, description, and culture in the Central Great Plains. U. S. Dept. Agric. Cir. 571: 1–20. *Fig. 1–10.*

ORCHARD, E. R. 1939. Compost: Its preparation and use. Union of South Africa Science Bull. 201: 1-28.

SARAO, F. B. 1918. Value of Philippine composts. The Philippine Agriculturist and Forester **6**: 128-134.

TABLE 1

Average rate of composting of rice straw alone, and rice straw alternated with soil, wood ash, carabao dung, and horse dung moistened with fifteen different fertilizer solutions

SERIES OF COMPOSTING MATERIALS	FERTILIZER							
	Water	N	P	K	Ca	N-P	N-K	P-K
Straw alone	80 ∓ 0.790	70 ∓ 0.790	81 ∓ 0.790	88 ∓ 0.790	93 ∓ 0.790	97 ∓ 0.790	72 ∓ 0.790	93 ∓ 0.790
Straw + soil	83 ∓ 0.790	74 ∓ 0.790	81 ∓ 0.790	88 ∓ 0.790	93 ∓ 0.790	97 ∓ 0.790	72 ∓ 0.790	93 ∓ 0.790
Straw + ash	98 ∓ 0.790	89 ∓ 0.790	101 ∓ 0.790	99 ∓ 0.790	135 ∓ 0.790	131 ∓ 0.790	87 ∓ 0.790	106 ∓ 0.790
Straw + carabao dung	80 ∓ 0.790	70 ∓ 0.790	78 ∓ 0.790	88 ∓ 0.790	93 ∓ 0.790	92 ∓ 0.790	72 ∓ 0.790	88 ∓ 0.790
Straw + horse dung	77 ∓ 0.790	70 ∓ 0.790	78 ∓ 0.790	88 ∓ 0.790	93 ∓ 0.790	92 ∓ 0.790	72 ∓ 0.790	88 ∓ 0.790

TABLE 1 (continued)

SERIES OF COMPOSTING MATERIALS	FERTILIZER							
	N-P-K	N-Ca	P-Ca	K-Ca	N-P-Ca	N-K-Ca	P-K-Ca	N-P-K-Ca
Straw alone	122 ∓ 1.118	99 ∓ 0.790	89 ∓ 0.790	96 ∓ 0.790	94 ∓ 0.790	89 ∓ 0.790	96 ∓ 0.790	119 ∓ 0.790
Straw + soil	126 ∓ 0.790	104 ∓ 0.790	89 ∓ 0.790	94 ∓ 0.790	94 ∓ 0.790	89 ∓ 0.790	96 ∓ 0.790	124 ∓ 0.790
Straw + ash	129 ∓ 0.790	126 ∓ 0.790	115 ∓ 0.790	174 ∓ 0.790	130 ∓ 0.790	100 ∓ 0.790	112 ∓ 0.790	151 ∓ 1.118
Straw + carabao dung	123 ∓ 0.790	99 ∓ 0.790	89 ∓ 0.790	93 ∓ 0.790	91 ∓ 0.790	85 ∓ 0.790	94 ∓ 0.790	123 ∓ 0.790
Straw + horse dung	129 ∓ 0.790	96 ∓ 0.790	89 ∓ 0.790	93 ∓ 0.790	91 ∓ 0.790	85 ∓ 0.790	94 ∓ 0.790	123 ∓ 0.790

TABLE 2

Average weight in grams of fresh pe-tsai (Brassica pekinensis Rupr.) planted in a mixture of equal weights of soil and composts

SERIES OF COMPOSTS	TREATMENT							
	Water	N	P	K	Ca	N-P	N-K	P-K
Straw alone	99.50∓ 5.59	194.17∓ 2.91	103.92∓6.34	112.00∓ 4.97	104.87∓13.84	200.82∓14.38	133.17∓12.15	97.25∓ 4.15
Straw + soil	122.85∓10.54	221.00∓26.08	189.20∓7.92	143.02∓15.54	115.12∓ 1.84	218.10∓ 9.86	274.57∓27.72	177.00∓12.45
Straw + ash	50.00∓ 5.00	45.75∓ 5.89	47.75∓4.43	58.75∓ 4.37	—	—	—	47.50∓ 2.60
Straw + carabao dung	268.02∓ 6.12	336.15∓27.90	297.87∓7.08	298.37∓35.61	268.92∓11.10	340.17∓20.18	355.50∓ 8.77	320.00∓ 7.90
Straw + horse dung	239.05∓24.67	306.17∓ 7.79	299.60∓5.38	214.42∓24.71	171.55∓ 9.50	315.25∓15.64	311.25∓ 4.60	312.50∓ 9.77
Control	85.77∓ 2.48	78.00∓ 2.86	97.80∓4.01	74.10∓ 4.15	91.92∓ 3.00	78.42∓ 2.44	82.10∓ 2.96	76.07∓ 3.66

TABLE 2 (continued)

SERIES OF COMPOSTS	TREATMENT							
	N-P-K	N-Ca	P-Ca	K-Ca	N-P-Ca	N-K-Ca	P-K-Ca	N-P-K-Ca
Straw alone	209.75∓2.07	151.95∓14.63	104.65∓ 7.59	154.50∓16.47	206.50∓ 5.63	200.00∓5.59	105.70∓3.67	213.75∓ 7.15
Straw + soil	209.00∓8.29	245.95∓ 9.38	187.30∓ 7.84	206.25∓29.30	222.80∓ 1.44	200.55∓4.35	199.00∓3.33	242.50∓ 9.39
Straw + ash	30	—	50.75∓ 3.75	86.00∓ 3.00	87.50∓ 0.88	102.50∓4.00	—	—
Straw + carabao dung	338.50∓0.78	377.60∓13.81	310.45∓ 6.67	305.00∓ 3.53	307.75∓ 4.39	312.50∓3.92	302.50∓3.38	343.75∓ 6.20
Straw + horse dung	325.00∓7.05	318.30∓12.66	282.50∓21.53	216.35∓30.73	332.00∓19.67	314.25∓6.50	306.57∓9.23	335.00∓10.30
Control	87.50∓0.95	78.80∓ 7.29	77.50∓ 3.73	85.30∓ 3.10	81.30∓ 3.70	77.60∓3.20	75.05∓3.93	79.00∓ 2.55

A COMPARATIVE STUDY ON THE VALUE OF SUGAR AND CORN AS BASAL FEEDS FOR GROWING AND FATTENING PIGS [1]

CORNELIO S. BINOYA

Abel (1917) states that for fat formation, sugar is like starch, and that the fat it produces in animals is firm and of good quality. She concludes that it takes the place of starch, weight for weight, if given in small quantities.

Comparing sugar and molasses with starch as parts of a ration for pigs, Meisel (1897) found that sugar hindered slightly the gain in muscular and fatty tissues, because of some secondary effect of sugar.

In the feeding experiments conducted by Malpeaux (1896) on bulls and heifers, 500 grams of brown sugar were added to the basal feed. The bulls made 7 kilogram and the heifers 8 kilogram more gain than those fed the same basal ration without sugar. For milch cows, the same author found that neither the yield nor the composition of milk was materially affected by the addition of sugar in their ration. The cows, however, gained somewhat more in weight than when no sugar was fed.

Bunger (1937), in summarizing the results obtained by Stahl *et al.* in feeding wood sugar to pigs, stated that wood sugar has a starch equivalent value of 62.1 per cent of dry sugar, which is about equal to cane sugar in nutritive value. In the case of sugar-potato mixture, the starch value was equal to that of potatoes alone, whereas sugar-barley mixture was inferior to barley alone.

The object of this study was to compare sugar and corn as basal feeds for growing and fattening pigs.

The experiment was started on July 16, 1938, and closed on February 11, 1939, covering a period of 210 days. It was conducted in the Department of Animal Husbandry, College of Agriculture.

Animals

Twenty-one weanling pigs were used in the experiment, fifteen of which were males and six, females.

[1] Experiment Station contribution No. 1406. Prepared in the Department of Animal Husbandry under the direction of Assistant Professor Mariano Mondoñedo.

Feeds

The feeds used were corn, sugar, rice bran, copra meal, and fish meal. The corn was the Yellow Flint variety and the sugar was the brown centrifugal cane sugar produced at the College Sugar Mill. The minerals consisted of burnt corn cob, lime, and common salt.

The average prices per kilogram of feeds at the time of the experiment were as follows: shelled corn, 6.2 centavos; fine rice bran, 5.5 centavos; copra meal, 4.2 centavos; fish meal, 13.2 centavos; and sugar, 10.8 centavos.

The ration mixtures for the three periods were as follows:

First 70-day period

	Lot I	*Lot II*	*Lot III*
Corn	15.0	7.5	0
Sugar	0	7.5	15.0
Rice bran	60.0	60.0	60.0
Copra meal	18.0	18.0	18.0
Fish meal	7.0	7.0	7.0
Total	100.0	100.0	100.0

Second 70-day period

	Lot I	*Lot II*	*Lot III*
Corn	25.0	12.5	0
Sugar	0	12.5	25.0
Rice bran	60.0	60.0	60.0
Copra meal	13.0	13.0	13.0
Fish meal	2.0	2.0	2.0
Total	100.0	100.0	100.0

Third 70-day period

	Lot I	*Lot II*	*Lot III*
Corn	35.0	17.5	0
Sugar	0	17.5	35.0
Rice bran	60.0	60.0	60.0
Copra meal	5.0	5.0	5.0
Fish meal	0	0	0
Total	100.0	100.0	100.0

Allotment of pigs

The pigs were divided into three lots of seven each. They were so divided as to make the lots as equal as possible in sex, weight, and condition. Lot I (corn lot) received the College standard rations. Lot II (sugar-corn lot) was given a ration wherein half of the corn

in the standard mixture was replaced by an equal amount of sugar. Lot III (sugar lot) was given the same ration as in the College standard rations except that the corn portion was replaced by an equal amount of sugar.

Feeding and management

Enough feed for each lot was mixed to last the pigs one week. Throughout the test period the pigs were dry lot fed twice a day, from 6:00 to 7:00 in the morning and from 4:00 to 5:00 in the afternoon. They were bathed before being fed. The feed was given in the form of slop in the proportion of about one part feed to three parts water by weight.

After being fed, the pigs were turned out into the paddock. At noon they were driven back to the hog house to drink and bathe after which they were put in a paddock bare of vegetation. They had access to the shelter of an acacia tree on one side of the lot.

The pigs were weighed weekly. For the initial weight the average of weights for three successive days was taken. The final weight was obtained in the same manner.

DISCUSSION OF RESULTS

The results of the experiment are summarized in tables 1 and 2.

In the course of the experiment, at about the close of the second 70-day period, hog cholera broke out in the College herd. Isolation of the herds and individual animals affected was strictly observed during the epidemic. At the close of the second 70-day period there were 5 pigs left in lot I, 5 in lot II, and 7 in lot III; at the end of the third 70-day period 2 pigs were left in lot I, 4 in lot II, and 3 in lot III.

The rate of gain of lot II pigs (sugar-corn lot) was consistently the most rapid. When treated statistically, the results were significantly better than those of lots I and III. The difference between the rate of gain of lots I and III was, however, not significant. Assuming the ration of lot I to be 100 per cent efficient, the ration of lot II throughout the feeding periods was 114 per cent efficient and that of lot III, 100 per cent, which shows that the combination of corn and sugar was better than the ration with either corn or sugar alone as the basal feed.

Judged on feed consumption per unit of gain, lot II pigs again were consistently the most economical throughout the feeding trials. Lot I was second during the first two 70-day periods and last in the third 70-day period. Assuming again the ration of lot I to be 100

per cent efficient, lot II throughout the feeding period was 117 per cent and lot III, 10 per cent better than lot I.

From the point of view of cost of feed to make a kilogram gain, lot II was the most economical except in the second 70-day period when it was second only to lot I. The average cost of feed per kilogram gain for the entire period was 34.21 centavos for lot II, 37.34 for lot I, and 39.49 for lot III. The reason for the cost of a kilogram gain in weight of lot II being more than that of lot I was that the cost of sugar, weight for weight, was more than that of corn.

Table 2 shows that the average amount of feed needed to make a kilogram gain was 6.48 kilograms in lot I, 5.40 kilograms in lot II, and 5.71 kilograms in lot III. Corn in lot I was 28 per cent of the total ration, corn and sugar in lot II was 14 per cent each, and sugar in lot III was 28 per cent. From these data, it is evident that the amount of corn needed to make a kilogram gain in lot I was 1.81 kilograms; in lot II, 0.76 kilogram each of sugar and corn; and 1.60 kilograms of sugar in lot III; that is, 1.81 kilograms of corn is equal in feeding value to 0.76 kilogram each of sugar and corn in lot II, and 1.60 kilogram sugar in lot III. In other words 1 kilogram of corn in lot I is equal to 0.42 kilogram of corn combined with 0.42 kilogram sugar in lot II, and 0.88 kilogram of sugar in lot III.

The question that naturally arises is what should be the price of sugar so that a kilogram gain in lots II or III would equal that of lot I?

At the time of this experiment, the price of corn was 6.2 centavos a kilogram; of sugar, 10.8 centavos. The difference of 3.13 centavos between the cost of a kilogram gain in lots I and II was due largely to the difference in the price of these feeds. The amount of sugar in 5.40 kilograms of feed consumed to make a kilogram gain in lot II was 0.756 kilogram, costing 8.16 centavos. To this should be added the difference of 3.13 centavos making the total cost 11.29 centavos to make a kilogram gain in lot II equal that of lot I. If the price of 0.756 kilogram sugar should be 11.29 centavos, then 1 kilogram of sugar can go as high as 14.9 centavos to equal the cost of gain in lot I.

Between lots I and III, the difference in the cost of a kilogram gain was 2.15 centavos in favor of lot I. The amount of sugar in the 5.71 kilograms of feed consumed for a kilogram gain in lot III was 28 per cent, or 1.60 kilograms, costing 17.28 centavos. Because a kilogram gain in lot III cost more than that in lot I, to justify the use of sugar, its price should go down; that is, from the actual price

of 1.60 kilograms sugar, which is 17.28 centavos. 2.15 centavos should be subtracted giving the difference of 15.13 centavos as the cost of 1.60 kilograms sugar. A kilogram of sugar, therefore, should go down to 9.5 centavos to equal the cost of a kilogram gain in lot I.

SUMMARY AND CONCLUSIONS

1. Sugar was as good as corn in its effect on the growth and development of pigs, there being no difference between lot I (corn lot) and lot III (sugar lot) in gain in weight. Lot II, which received the sugar-corn ration, made the most rapid gain in weight. With the corn ration (lot I, the control lot) assumed to be 100 per cent efficient, lot II was 117 per cent, and lot III, 100 per cent efficient.

2. In the amount of feed required to make a kilogram gain in weight, lot I was found to have consumed the most, lot III the second, and lot II the least.

3. In feed cost, based on the current prices of feeds at the time the experiment was conducted, the most expensive gain was made by lot III (sugar lot), and the most economical, by lot II (corn-sugar lot).

4. With sugar selling at 10.8 centavos a kilogram and corn at 6.2 centavos, corn was only slightly more profitable as basal feed than sugar. The combination of corn and sugar was more profitable than either corn or sugar alone as basal feed.

5. One kilogram of corn is equal to 0.88 kilogram of sugar when used entirely to replace corn; the same amount of corn is equivalent to 0.42 kilogram of sugar combined with 0.42 kilogram of corn.

6. With the prices of other constituents of the ration remaining the same, sugar in combination with corn in the ration may be profitably fed to growing and fattening pigs even if the price of sugar rises to 14.9 centavos a kilogram.

7. If sugar is used alone as the basal feed, it can profitably be fed to growing and fattening pigs provided the price is 9.5 centavos a kilogram.

LITERATURE CITED

ABEL, MARY H. 1917. Sugar and its value as food. U. S. Dept. Agric. Farmers' Bull. 355: 1–30.

MALPEAUX, L. 1896. The use of sugar in feeding animals. Ann. Agron. 22: 281–296, *Cited in* U. S. Dept. Agric. Exper. Sta. Rec. 8: 323.

MEISEL, E. 1897. Experiment with pigs. Chem. Ztg. 21: 7,311. *Cited in* U. S. Dept. Agric. Exper. Sta. Rec. 8: 7.

STAHL,—*et al.* 1936. The use of wood sugar in pig fattening. (Trans. title by Bunger) Ztshr. Schveinezucht 43: 471–493. *Cited in* U. S. Dept. Agric. Exper. Sta. Rec. 77: 836.

TABLE 1

Average results obtained in the first, second, and third seventy-day periods of the experiment

ITEMS	LOT I Corn	LOT II Corn-sugar	LOT III Sugar
First seventy-day period			
Daily gain per pig, in kg.	0.23	0.25	0.22
Daily ration per pig, in kg.	0.81	0.82	0.81
Daily ration per 100 kg. live weight, in kg.	4.08	3.95	4.21
Feed consumed per kg. gain, in kg.	3.60	3.23	3.69
Feed cost per kg. gain, in centavos	20.76	20.45	25.50
Second seventy-day period			
Daily gain per pig, in kg.	0.23	0.26	0.23
Daily ration per pig, in kg.	1.34	1.42	1.40
Daily ration per 100 kg. live weight, in kg.	3.74	3.67	3.93
Feed consumed per kg. gain, in kg.	5.79	5.51	5.97
Feed cost per kg. gain, in centavos	33.37	34.95	41.28
Third seventy-day period			
Daily gain per pig, in kg.	0.19	0.24	0.21
Daily ration per pig, in kg.	1.93	1.81	1.57
Daily ration per 100 kg. live weight, in kg.	3.81	3.22	3.06
Feed consumed per kg. gain, in kg.	10.05	7.45	7.48
Feed cost per kg. gain, in centavos	57.89	47.23	51.67

TABLE 2

Average results obtained in the entire feeding test of 210 days

ITEMS	LOT I	LOT II	LOT III
Initial weight per pig, in kg.	11.99	11.91	11.00
Final weight per pig, in kg.	57.38	64.70	58.58
Daily ration per pig, in kg.	1.36	1.35	1.26
Daily ration per 100 kg. live weight, in kg.	3.92	3.52	3.48
Daily gain per pig, in kg.	0.22	0.25	0.22
Feed consumed per kg. gain, in kg.	6.48	5.40	5.71
Feed cost per kg. gain, in centavos	37.34	34.21	39.49
Comparative efficiency of the rations:			
a. based on rapidity of gain, in per cent	100	114	100
b. based on economy in feed per unit of gain, in per cent	100	117	110
c. based on feed cost per unit of gain, in per cent	100	120	95

A STUDY OF FERTILIZERS WITH ONIONS GROWN ON LIPA CLAY LOAM IN POTS [1]

ANTONIO C. BELLO

WITH ONE TEXT FIGURE

The growing of onions as a minor crop, usually in rotation with rice or corn, is becoming popular in many provinces in the Philippines. One phase of its culture which the farmers know little about is the use of commercial fertilizers to increase production. Only two fertilizer tests have so far been made with onions in the Philippines (Elayda, 1935, and Rodrigo, 1936).

Review of literature

Gaskill (1919) reported that barnyard manure, nitrate of soda, sulfate of ammonia, and dried blood were beneficial to onions. Lloyd and Lewis (1931) observed the value of supplementing manure or nitrate with commercial fertilizer, especially phosphate, and found that neither nitrate nor manure alone was sufficient to produce good results. Fite (1935) found that manure applied early at the rate of 10 tons per acre and supplemented with 300 to 400 pounds of ammonium sulfate gave good yields. Hawthorn (1936) reported that a mixture of sulfate of ammonia and of 18 per cent superphosphate at the rate of 600 pounds per acre of the formula 6-12-0 was more effective in increasing yields of onions than was the superphosphate alone.

Jones and Snell (1930) reported that lime was indispensable for onions in acid soils. The average of the results of four years' work with lime used in onion culture showed an increase of 70 per cent in the yield of onions.

Knott (1933) reported that increased yields of onions were obtained after the application of 300 pounds of finely ground copper sulfate to the acre of muck soil concurrently supplied with a complete fertilizer. He observed that the tops did not die soon when copper sulfate was applied. A similar result was obtained by Beaumont, Snell, Doran, and Bourne (1935). These workers observed the

[1] Experiment Station contribution No. 1407. Prepared in the Department of Agricultural Botany under the direction of Professor Rafael B. Espino.

premature death of the tops of onions, or "blasting", which occurred late in July "when periods of rain were interrupted or followed by high temperature, bright sunlight, and drying winds". They observed, however, that the tops of onions were less susceptible to this "blast", and the bulbs were able to complete their normal development when the plants were treated with copper sulfate.

Objects of this study

The objects of this study were: (*a*) to compare the fertilizing values of Arcadia sodium nitrate and ammonium sulfate for onions when grown in Lipa clay loam, (*b*) to determine the fertilizing values for onions of these two nitrogenous fertilizers when mixed together, and (*c*) to determine whether or not the growth and yield of onions could be improved with the use of certain kryptotrophic, or secondary essential elements.

Time and place of this study

The experiments were conducted in the experimental yard of the Department of Agricultural Botany, College of Agriculture, from January 8, 1939, to April 27, 1940.

MATERIALS AND METHODS

Soil

Lipa clay loam which had never been treated with any fertilizer was gathered near the Rural High School Reservation. The soil was pulverized, sifted, and thoroughly mixed. About thirty-six kilograms of soil was placed in each big pot and about ten kilograms of soil in each small pot. As previously analyzed by the Department of Agricultural Chemistry, samples of similar soil were found to contain 0.00264 per cent available N, 0.00279 per cent available P_2O_5, and 0.02228 per cent available K_2O[2].

Plants

Bermuda onion plants were grown from seeds obtained from a dealer in Lemery, Batangas. The seeds were soaked in water for twelve hours and then sown in seed boxes. They germinated in about twelve to fourteen days after being sowed. When about three weeks old, the seedlings were pricked and transferred to other

[2] MADRIGAL, JOSÉ, Jr. Determination of fertilizer requirements of corn plant when grown in Lipa clay loam. Thesis presented for graduation with the degree of Bachelor of Science in Agriculture, College of Agriculture, University of the Philippines. 1940. (Unpublished).

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boxes, where they were planted a little further apart. When about six weeks of age, seedlings were transplanted to the culture pots. Transplanting was done late in the afternoon so as to protect the young plants from the heat of the sun.

Fertilizers and kryptotrophic elements

Arcadia sodium nitrate. This fertilizer was obtained from Menzi & Co., Inc., and contained 16 per cent N. The rate of application of the fertilizer and the amount of nitrogen added to the soil of each pot are given in table 1. Unfertilized pots for control were used.

Ammonium sulfate. The fertilizer was obtained also from Menzi & Co., Inc., and was reported to contain 20.6 per cent N. It was added to the soil in pots at the rate given in table 1. Control or unfertilized cultures were also included in this set. The amounts of N employed were similar to those in the Arcadia sodium nitrate set as shown in table 1.

Mixture of ammonium sulfate and sodium nitrate. Combinations of the two nitrogenous fertilizers were applied to the soil in pots at the rates shown in tables 3 and 4. Control or unfertilized cultures were also included in this set. The amounts of N used in this set of cultures are listed in tables 3 and 4.

Cultures with kryptotrophic elements. From the three types of cultures previously tried, the best for onions, especially in the production of bulbs, was selected. This culture contained 9.1 grams of ammonium sulfate and 11.8 grams of Arcadia sodium nitrate. This mixture was used as the basal fertilizer application to Lipa clay loam contained in large pots for four onion plants. To this mixture was added singly or in certain combinations kryptotrophic or secondary essential elements, namely, manganese, boron, zinc, and copper. The Mn was applied as $MnSO_4$; the B, as $Na_2B_4O_7$; the Zn, as $ZnSO_4$; and the Cu, as $CuSO_4$. The exact amounts employed are recorded in tables 5 and 6. Unfertilized pots, serving as control, were also employed.

In later cultures, smaller earthen pots were used. Proportional to the reduction in the area of the pot, the amounts of ammonium sulfate and of Arcadia sodium nitrate were also reduced. To each of the smaller pots, 2.8 grams of ammonium sulfate and 3.6 grams of sodium nitrate were added. Each smaller pot contained only one plant. To the basal application of the two nitrogenous fertilizers in

the smaller pots were added in varying amounts each of the four kryptotrophic elements tested (table 5).

The most promising cultures containing kryptotrophic elements were then noted. Four cultures were selected and each was found to contain, aside from the 2.8 grams of ammonium sulfate and 3.6 grams of sodium nitrate, 0.3 gram of $MnSO_4$, 0.3 gram of $Na_2B_4O_7$, 0.1 gram of $ZnSO_4$, or 0.2 gram of $CuSO_4$. These cultures were tried singly as before and also in three combinations. The exact amounts of the nitrogenous fertilizers and of the kryptotrophic elements employed are recorded in table 6. Suitable control cultures were also employed.

Care of the culture

The cultures were conducted in the open, directly exposed to the sun and rain. They were cultivated from time to time and watered almost daily. Weeding was done whenever necessary.

Harvesting

Harvesting was done by pulling the onion plants from the pots, since the bulbs were practically on the surface of the soil. Maturity was indicated by the shriveling or softening of the "neck" and drying of most of the leaves.

EXPERIMENTS AND RESULTS

Pot cultures tried and results obtained

To compare the fertilizing values of Arcadia sodium nitrate and ammonium sulfate for onions when grown in Lipa clay loam. This set was started on January 8, 1939, and was harvested on May 29, 1939. Data on the height of plants, dry weight of leaves, and fresh weight of bulbs were taken (table 1). This set was repeated on November 10, 1939, and the experimental data obtained are recorded in table 2.

To determine whether the fertilizing values of the two nitrogenous fertilizers could be improved for onions if mixed together. The cultures containing mixtures of sodium nitrate and ammonium sulfate were started also on January 8, 1939. The results of these cultures are recorded in table 3. A similar set of cultures was started on November 10, 1939, and harvested on March 31, 1940. The data obtained are recorded in table 4.

To determine whether or not the growth and yield of onion could be improved with the application of kryptotrophic elements. These

cultures were started on November 26, 1939; on April 7, 1940, the plants were harvested (table 5).

The most promising rate of application of each of the four kryptotrophic elements employed was noted. The selected cultures were repeated, supplied with the kryptotrophic elements singly and in combinations, such as Mn and B; Mn, B, and Zn; and Mn, B, Zn, and Cu. This set of cultures was started on December 16, 1939, and on April 27, 1940, the cultures were harvested and the results recorded in table 6.

Criteria of results

The criteria of results were (*a*) height of plants, (*b*) dry weight of leaves, (*c*) fresh weight of bulbs, and (*d*) shape of bulb. The data for each criterion were gathered as follows:

a. Height of plants. The data on the height of the plants were obtained at the time of harvest. Measurements were made from the base of the "neck" of the bulbs in each culture to the tip of the longest leaf.

b. Dry weight of leaves. After being separated from the bulbs, the leaves were wrapped in paper, tied, and labeled. They were then dried, first in the sun and later in an electric oven. After drying, the tops from each culture were weighed.

c. Fresh weight of bulbs. Soon after the bulbs were harvested, or the leaves cut from the "neck", the bulbs, were weighed.

d. Shape of bulbs. They were classified into oblong, rounded, flattened, and twin.

DISCUSSION OF RESULTS

Effects of sodium nitrate

Tables 1 and 2 show that the onion plants responded to the applications of Arcadia sodium nitrate to the Lipa clay loam. Under the three criteria of results employed, it may be said that the higher the application of sodium nitrate, the better were the results obtained, with the control, or the unfertilized cultures, giving always the lowest yield values.

Cultures V and VI, with culture VI apparently a little better than culture V, gave the highest values under each criterion of results employed in tables 1 and 2. Statistical comparison of bulbs from these two cultures revealed that the value of the difference was insignificant in table 1 and only slightly significant in table 2.

Since culture VI, which had four onion plants, received 19.6 grams of sodium nitrate or 3.13 grams of nitrogen, the highest ap-

plication tried, it is not known whether a greater application would give a correspondingly higher yield. The fact remains that although the onion bulbs produced in these two sets of sodium nitrate-treated cultures increased in size and weight with the increase of the fertilizer, they were nevertheless rather small. It appears, therefore, that the Arcadia sodium nitrate when added to Lipa clay loam, was not quite suitable for onions.

Effects of ammonium sulfate

Tables 1 and 2 show that applications of ammonium sulfate to Lipa clay loam were, within limits, beneficial to onion plants. Under the criteria of results employed, all the fertilized cultures were better than the control, or the pot that received no ammonium sulfate. The two most promising cultures of onions appeared to be IVa and Va, with the former slightly better than the latter. Culture IVa had four plants and it received 9.1 grams of ammonium sulfate containing 1.87 grams of nitrogen.

The yield of onion bulbs in culture IVa was significantly greater than that of any other culture except Va and VIa.

Comparing sodium nitrate and ammonium sulfate

The best sodium nitrate-treated culture and the best ammonium sulfate-treated culture in tables 1 and 2 were selected and the data obtained under each of the criteria employed were compared in table A.

TABLE A

(Experiment, January 8 to May 29, 1939)

CULTURE NO.	TREATMENT GIVEN		HEIGHT OF PLANTS	DRY WEIGHT OF LEAVES	FRESH WEIGHT OF BULBS
	Amount of fertilizer	Amount of N			
	grams	*grams*	*cm.*	*grams*	*grams*
IVa	9.1	1.87	46.84 ∓ 1.19	1.53 ∓ 0.041	37.49 ∓ 1.08
VI	19.6	3.13	41.96 ∓ 0.82	1.12 ∓ 0.023	11.01 ∓ 0.27
Difference			4.88 ∓ 1.44	0.41 ∓ 0.046	26.48 ∓ 1.11
Percentage of difference			10.4	26.6	70.6
(Experiment, November 10, 1939, to March 31, 1940)					
IVa	9.1	1.87	51.01 ∓ 0.62	1.64 ∓ 0.073	53.11 ∓ 1.29
VI	19.6	3.13	42.56 ∓ 0.79	1.17 ∓ 0.016	29.44 ∓ 0.80
Difference			8.45 ∓ 0.98	0.47 ∓ 0.074	23.67 ∓ 1.51
Percentage of difference			16.5	28.7	44.6

In table A, culture IVa, which received 9.1 grams of ammonium sulfate containing 1.87 grams of N, was better than the corresponding culture VI, which received 19.6 grams of sodium nitrate containing 3.13 grams of N. The difference in the fresh weight of bulbs between these two cultures was most pronounced. With the fresh weight of bulbs as the criterion, the difference rose to as high as 70.6 per cent in one set of cultures and 44.6 per cent in the other set, in favor of ammonium sulfate. It appeared, therefore, that the ammonium sulfate was much more beneficial to onions than the Arcadia sodium nitrate. Moreover, 1.87 grams of N from the sulfate of ammonia produced twice as many onion bulbs as the 3.13 grams of N from the Arcadia sodium nitrate. Therefore, gram for gram, the nitrogen in ammonium sulfate was far more effective for onions than the nitrogen in Arcadia sodium nitrate.

Even when the comparison of the results obtained was made on the basis of the total amount of nitrogen added to the soil in the five fertilized cultures in each set, ammonium sulfate was more beneficial to onions than sodium nitrate as shown in table B.

TABLE B

(First set)

SOURCE OF N	TOTAL N ADDED	HEIGHT OF PLANTS	DRY WEIGHT OF LEAVES	FRESH WEIGHT OF BULBS
	grams	*cm.*	*grams*	*grams*
Ammonium sulfate	9.37	218.92	6.45	146.12
Sodium nitrate	9.38	176.85	3.93	29.72
Difference		42.07	2.52	116.40
Percentage of difference		19.2	39.0	79.6
(Second set)				
Ammonium sulfate	9.37	238.49	7.07	205.73
Sodium nitrate	9.38	181.57	4.21	91.58
Difference		56.92	2.86	114.15
Percentage of difference		23.8	40.4	55.6

Table B shows that in fresh weight of onion bulbs, the difference was as high as 79.6 per cent in the first set of cultures and 55.6 per cent in the second set, in favor of ammonium sulfate-treated cultures.

Effects of mixtures of sodium nitrate and ammonium sulfate

Tables 3 and 4 reveal that cultures XIII and XIV were the two highest yielders based on the three criteria of results employed. These cultures were supplied with mixtures of ammonium sulfate and sodium nitrate.

The yields of bulbs of these two cultures were actually compared, and the difference was found statistically significant in the first trial and insignificant in the second. When compared with the yields of the other cultures, with but one exception, these cultures was significantly better. Only in one trial was the difference in the yields of onion bulbs from cultures XIV and XV statistically insignificant.

Inasmuch as culture XIII was actually better, especially in yield of bulbs, than any of the other cultures tried, it might be of interest to look into the characteristics of the growth factor constituents of this culture. This culture received 1.87 grams of N from ammonium sulfate and 1.88 grams of N from the Arcadia sodium nitrate. To all intents and purposes, it might be said that the amounts of N from these two nitrogenous fertilizers were almost equal.

Further study of the fertilizer mixtures employed (tables 3 and 4) showed that the highest yield data were obtained not always from the cultures that received 3.74, 3.75, or 3.77 grams of total N, the three highest amounts tried in the two sets. The best results appeared to have been obtained from the cultures with relatively high amounts of ammonium sulfate and a moderate or low amount of sodium nitrate. As may be recalled, the 9.1 grams of ammonium sulfate gave the highest yield of onion bulbs. This culture received 1.87 grams of N. Incidentally, in the mixtures of ammonium sulfate and sodium nitrate, the highest yield of onion bulbs was obtained also from a culture containing 9.1 grams of ammonium sulfate with 1.87 grams of N and a moderate amount of sodium nitrate.

When the amount of ammonium sulfate was increased to 12.2, or 15.3 grams per pot, although accompanied with some sodium nitrate, the yield of onion bulbs decreased. On the other hand, in other cultures when 9.1 grams of ammonium sulfate with less than 11.8 grams of sodium nitrate were added to each pot, adverse results were also obtained.

The most beneficial mixture of these two nitrogen carriers for Lipa clay loam in pots with four onion plants appears, therefore, to be one containing 9.1 grams of ammonium sulfate and 11.8 grams of

sodium nitrate. The nitrogen contents of the two fertilizers are practically the same.

Tables 3 and 4 show that in the two trials, culture XIII, which received almost equal amounts of N from the two N-carriers, gave far better results than either culture XVII, the best in the sodium nitrate set, or XVIII, the best among the cultures that received varying amounts of ammonium sulfate. Therefore, for onion plants when grown in Lipa clay loam, a mixture of ammonium sulfate and sodium nitrate was better than either the two fertilizers alone.

Effects of kryptotrophic elements

Table 5, culture I, shows that Lipa clay loam which did not receive fertilizer or any of the kryptotrophic elements gave the lowest yield values. When a mixture of 2.8 grams of ammonium sulfate and 3.6 grams of sodium nitrate was added to the culture (II or IIa), the yield data obtained were increased considerably. The addition of a kryptotrophic element to each of the remaining twenty cultures containing the mixture of the two N-carriers appeared to have produced further increases in the yield data, especially in fresh weight of onion bulbs. Whether or not these apparent increases in yield data are significant remains to be seen.

Since the data in table 5 on height of plants and dry weight of leaves showed little divergence the yield of onion bulbs seemed the best criterion to use; therefore further study of the comparative nutritive values of the different cultures in table 5 was based on the fresh weight of bulbs.

A more meticulous study of the data in table 5 led to the selection of cultures VI, XI, IVa, and Xa as giving the highest yield value of onion bulbs from cultures that received varying amounts of each of the four kryptotrophic elements employed.

Before the selected cultures were compared with one another, comparisons of each of these cultures with the cultures in table 5, which received the kryptotrophic elements, were statistically made. The results were the following:

(*a*) Culture VI was significantly better than III, V, and VII, but its difference from IV was insignificant. Therefore, although 0.3 gram of $MnSO_4$ per pot gave apparently the highest yield of onion bulbs, nevertheless a lower application might be just as good.

(*b*) Culture XI was significantly better than VIII, IX, and XII, but its difference from X was insignificant. Therefore, application

to Lipa clay loam of $Na_2B_4O_7$ at the rate of 0.3 gram per pot containing one onion plant gave the highest yield of bulbs.

(*c*) Culture IVa was significantly better than IIIa, Va, VIa, and VIIa. Therefore, application to Lipa clay loam of $ZnSO_4$ at the rate of 0.1 gram per pot of one onion plant gave the highest yield of bulbs.

(*d*) Culture Xa was significantly better than VIIIa, XIa, and XIIa; but its difference from IXa was insignificant. Therefore, application to Lipa clay loam of $CuSO_4$ at the rate of 0.1 or 0.2 gram per pot of one onion plant gave the highest yield of bulbs.

The data under the four selected high yielders referred to were next statistically compared with one another, mainly with culture IVa as the pivot. The results showed that the yield of culture IVa was

Fig. 1.—Onion bulbs and tops. Cultures I to VIII were each supplied with a mixture of sulfate of ammonia and nitrate of soda to which were added the four kryptotrophic elements, Mn, B, Zn, and Cu singly or in combination (table 6). Photograph by the Photographic Division, College of Agriculture.

greater than that of VI, and slightly better than that of XI, but the value of the difference between the yield of IVa and that of Xa was highly insignificant. When the yield of Xa was, however, compared with that of VI and with that of XI, the values of the differences obtained were highly insignificant. Therefore, it appeared that IVa, which received in addition to the two N-carriers 0.1 gram of $ZnSO_4$ per plant, was probably the best in the lot, with Xa, which had 0.2 gram of $CuSO_4$, a close second and better than either VI, which received 0.3 gram of $MnSO_4$, or XI, which had 0.3 gram of $Na_2B_4O_7$ per plant.

Further study on the effects of kryptotrophic elements

The four most promising cultures in table 5 were again tried with the kryptotrophic elements employed singly and in certain combinations. The object was to find out if mixtures of Mn and B; Mn, B, and Zn; and Mn, B, Zn, and Cu might not further improve the growth and the yield of onions.

The results also showed that the addition of the kryptotrophic elements had again further improved the growth of the plants and increased the yield of bulbs over and beyond that of those treated with the two N-carriers, but without any of the secondary essential elements.

The kryptotrophic element-treated cultures were next compared with one another (cultures III to IX in table 6). Cultures VII, VIII, and IX gave apparently the highest yield data of the lot. Further comparisons, especially of these three most promising cultures, were made on the basis of the yield of onion bulbs. The values of the differences obtained were, however, all statistically insignificant. Therefore, these three cultures were equally effective in producing onion bulbs.

When the yields of onion bulbs from the three apparently most suitable cultures (VII, VIII, and IX) were statistically compared with those obtained from cultures III, IV, V, and VI, no significant difference was found except in that from III. From these results two conclusions were inevitable, namely, (*a*) that as in the preceding culture set (table 5), III, which in addition to the nitrogenous fertilizers received 0.3 gram of $MnSO_4$, was not so effective in inducing the production of onion as IV, which received 0.3 gram of $Na_2B_4O_7$, or as V, which was supplied with 0.1 gram of $ZnSO_4$, or VI, which received 0.2 gram of $CuSO_4$ per pot; and (*b*) that the mixtures of these four secondary essential elements tried were not statistically superior to, or better than, any of the cultures supplied singly with boron, zinc, and copper.

Shapes of onion bulbs produced

The onion bulbs harvested were not only of different sizes and weights but of different shapes as well. The data on weights and shapes of bulbs have been studied.

In a general way, the data showed that certain shapes of the bulbs, seemed to be somewhat correlated with the fertility of the culture media employed. For instance, the unfertilized cultures pro-

duced bulbs that were either oblong or rounded. Not a single case was found in which the bulb was either flattened or twin.

Moreover, sodium nitrate, which was found not wholly suitable for onions when added alone to Lipa clay loam, produced bulbs mostly oblong and rounded in shape. On the other hand, the ammonium sulfate, which was found to be more suitable for onions, produced largely rounded or flattened bulbs. Furthermore the flattened onion bulbs were produced in those cultures more liberally supplied with nitrogen. A summary of the data on shapes of bulbs is given in table C.

TABLE C

CULTURE TYPE	OBLONG	ROUNDED	FLATTENED	TWINS
NO_3-treated	43	34	1	2
NH_4-treated	18	35	29	2
NO_3 + NH_4-treated	24	50	63	14
Mn-treated	0	2	22	0
B-treated	0	4	19	1
Zn-treated	0	3	18	3
Cu-treated	0	2	18	4
Soil only[a]	20	12	0	0

[a] Based on the sum of the data obtained from four sets of cultures.

Table C reveals (*a*) that the NO_3-treated cultures produced mostly oblong and rounded bulbs, (*b*) that NH_4-treated cultures produced mostly flattened bulbs, and (*c*) that the NO_3 + NH_4-treated cultures produced mostly flattened but some rounded bulbs.

The kryptotrophic elements-treated cultures (table C) had no oblong bulbs and relatively few rounded ones. Bulbs with a flattened shape were more numerous. It may thus be concluded that the secondary essential elements Mn, B, Zn, and Cu when added to Lipa clay loam had the tendency to produce flattened onion bulbs.

SUMMARY AND CONCLUSIONS

1. Arcadia sodium nitrate was not wholly suitable for onions when grown in Lipa clay loam in pots.

2. Gram for gram of nitrogen, ammonium sulfate was far more effective for onions than the Arcadia sodium nitrate.

3. Mixtures of ammonium sulfate and sodium nitrate were better for onion plants when grown in Lipa clay loam than either of the two nitrogenous fertilizers alone.

4. The mixture of the two nitrogen-carriers most beneficial to onion plants when grown in Lipa clay loam in pots consisted of 9.1 grams of ammonium sulfate and 11.8 grams of sodium nitrate, and the nitrogen contents of the two fertilizers were practically the same.

5. Culture IVa, which received, in addition to the two N-carriers, 0.1 gram of $ZnSO_4$ per plant, was the best in the lot, with Xa, which had 0.2 gram of $CuSO_4$, a closer second than either VI, which received 0.3 gram $MnSO_4$, or XI, which had 0.3 gram of $Na_2B_4O_7$ per plant.

6. Sodium nitrate cultures produced mostly oblong and rounded bulbs, whereas ammonium sulfate cultures produced bulbs that had the tendency to assume the flattened shape, and the mixture of sodium nitrate and ammonium sulfate produced bulbs not only mostly rounded and flattened, but a rather large number were twins.

7. In the kryptotrophic elements-treated cultures, the addition of Mn, B, Zn, and Cu to Lipa clay loam had the tendency to produce flattened onion bulbs.

LITERATURE CITED

Beaumont, A. B., M. E. Snell, W. L. Doran, and A. I. Bourne. 1935. Onions in Connecticut Valley. Massachusetts Agric. Exper. Sta. Bull. 318: 1–31.

Elayda, Aniano. 1935. Bermuda onion *Allium cepa*. Philippine Jour. Agric. 6: 175–191.

Fite, A. B. 1935. Onion fertilizer experiments. New Mexico Agric. Exper. Sta. Bull. 233: 1–22.

Gaskill, E. F. 1919. Report of soil fertility in Massachusetts. Massachusetts Exper. Sta. Rept. U. S. Exper. Sta. Rec. 41: 21.

Hawthorn, L. R. 1936. Fertilizer experiment with yellow Bermuda onion in Wonder Garden region of Texas. Texas Agric. Exper. Sta. Bull. 524: 1–35.

Jones, J. P., and M. E. Snell. 1930. Horticultural investigations at the Massachusetts Station. Massachusetts Exper. Sta. Rept. U. S. Exper. Sta. Rec. 63: 531.

Knott, J. E. 1933. The effect of certain mineral elements on the color and thickness of onion scales. Cornell Agric. Exper. Sta. Bull. 552: 1–14.

Lloyd, J. W., and E. P. Lewis. 1931. Horticultural investigations at the Illinois Station. Illinois Sta. Rept. U. S. Exper. Sta. Rec. 64: 837.

Rodrigo, Pedro A. 1936. Preliminary studies on the use of Bermuda onion as a rotation crop with lowland rice. Philippine Jour. Agric. 7: 317–324.

TABLE 1

Average data obtained from onion plants grown in Lipa clay loam in pots (4 plants per pot) supplied with different fertilizer mixtures of ammonium sulfate and sodium nitrate (Experiment from November 10, 1939, to March 31, 1940)

(a) Sodium nitrate

CULTURE NO.	AMOUNT OF FERTILIZER USED	AMOUNT OF NITROGEN	HEIGHT OF PLANT	DRY WEIGHT OF LEAVES	FRESH WEIGHT OF BULBS
	grams	*grams*	*cm.*	*grams*	*grams*
I	0	0	22.82 ∓ 0.78	0.19 ∓ 0.005	0.94 ∓ 0.12
II	3.9	0.62	26.44 ∓ 1.06	0.58 ∓ 0.007	1.99 ∓ 0.14
III	7.8	1.24	31.89 ∓ 0.66	0.63 ∓ 0.008	3.06 ∓ 0.17
IV	11.8	1.88	37.64 ∓ 0.82	0.77 ∓ 0.007	5.05 ∓ 0.24
V	15.7	2.51	38.92 ∓ 0.32	0.83 ∓ 0.016	8.61 ∓ 0.21
VI	19.6	3.13	41.96 ∓ 0.82	1.12 ∓ 0.025	11.01 ∓ 0.27

(b) Ammonium sulfate

Ia	0	0	22.82 ∓ 0.78	0.19 ∓ 0.005	0.94 ∓ 0.12
IIa	3.0	0.61	36.53 ∓ 1.14	0.86 ∓ 0.012	10.24 ∓ 0.36
IIIa	6.1	1.23	42.37 ∓ 0.72	1.06 ∓ 0.093	23.54 ∓ 1.11
IVa	9.1	1.87	46.84 ∓ 1.19	1.53 ∓ 0.041	37.49 ∓ 1.08
Va	12.2	2.51	46.64 ∓ 1.45	1.51 ∓ 0.047	37.46 ∓ 0.63
VIa	15.3	3.15	46.54 ∓ 1.11	1.49 ∓ 0.044	37.40 ∓ 0.90

TABLE 2

Average data obtained from onion plants grown in Lipa clay loam in pots (4 plants per pot) supplied with certain fertilizers (Experiment from November 10, 1939, to March 31, 1940)

(a) Sodium nitrate

CULTURE NO.	AMOUNT OF FERTILIZER USED	AMOUNT OF NITROGEN	HEIGHT OF PLANT	DRY WEIGHT OF LEAVES	FRESH WEIGHT OF BULBS
	grams	*grams*	*cm.*	*grams*	*grams*
I	0	0	24.63 ∓ 0.71	0.18 ∓ 0.008	4.32 ∓ 0.42
II	3.9	0.62	28.21 ∓ 0.90	0.57 ∓ 0.007	9.76 ∓ 0.72
III	7.8	1.24	31.72 ∓ 0.60	0.63 ∓ 0.010	12.39 ∓ 1.43
IV	11.8	1.88	38.44 ∓ 0.59	0.85 ∓ 0.016	17.36 ∓ 1.27
V	15.7	2.51	40.64 ∓ 0.68	1.05 ∓ 0.011	23.63 ∓ 2.30
VI	19.6	3.13	42.56 ∓ 0.78	1.17 ∓ 0.016	29.44 ∓ 0.80

(b) Ammonium sulfate

Ia	0	0	24.63 ∓ 0.71	0.18 ∓ 0.008	4.32 ∓ 0.42
IIa	3.0	0.61	40.16 ∓ 1.36	1.13 ∓ 0.055	20.86 ∓ 1.86
IIIa	6.1	1.23	48.97 ∓ 0.70	1.41 ∓ 0.043	39.75 ∓ 1.95
IVa	9.1	1.87	51.01 ∓ 0.62	1.64 ∓ 0.073	53.11 ∓ 1.29
Va	12.2	2.51	49.42 ∓ 0.36	1.46 ∓ 0.025	46.30 ∓ 2.01
VIa	15.3	3.15	48.93 ∓ 0.39	1.43 ∓ 0.021	45.71 ∓ 2.91

TABLE 3

Average data obtained from onion plants grown in Lipa clay loam in pots (4 plants per pot) supplied with different fertilizer mixtures of ammonium sulfate and sodium nitrate
(Experiment from January 8, 1939, to May 29, 1939)

CULTURE NO.	AMMONIUM SULFATE		SODIUM NITRATE		TOTAL AMOUNT OF NITROGEN	HEIGHT OF PLANT	DRY WEIGHT OF LEAVES	FRESH WEIGHT OF BULBS
	Amount used	N content	Amount used	N content				
	grams	*grams*	*grams*	*grams*	*grams*	*cm.*	*grams*	*grams*
I	0	0	0	0	0	22.82 ∓ 0.078	0.19 ∓ 0.005	0.94 ∓ 0.12
II	3.0	0.61	3.9	0.62	1.23	39.00 ∓ 1.85	0.97 ∓ 0.010	11.22 ∓ 0.12
III	3.0	0.61	7.8	1.24	1.85	39.98 ∓ 2.20	0.97 ∓ 0.015	15.05 ∓ 1.18
IV	3.0	0.61	11.8	1.88	2.49	39.63 ∓ 1.95	0.99 ∓ 0.017	15.79 ∓ 0.99
V	3.0	0.61	15.7	2.51	3.12	38.81 ∓ 2.42	0.98 ∓ 0.019	19.44 ∓ 0.81
VI	3.0	0.61	19.6	3.13	3.74	41.86 ∓ 1.63	1.07 ∓ 0.020	32.86 ∓ 0.92
VII	6.1	1.23	3.9	0.62	1.85	45.17 ∓ 1.98	1.25 ∓ 0.022	34.45 ∓ 1.08
VIII	6.1	1.23	7.8	1.24	2.47	41.10 ∓ 1.98	1.12 ∓ 0.017	36.22 ∓ 1.10
IX	6.1	1.23	11.8	1.88	3.11	43.30 ∓ 1.59	1.18 ∓ 0.016	36.95 ∓ 0.77
X	6.1	1.23	15.7	2.51	3.74	45.70 ∓ 1.78	1.33 ∓ 0.013	41.63 ∓ 1.96
XI	9.1	1.87	3.9	0.62	2.49	46.50 ∓ 1.33	1.38 ∓ 0.014	49.40 ∓ 1.12
XII	9.1	1.87	7.8	1.24	3.11	49.17 ∓ 2.60	1.44 ∓ 0.018	50.54 ∓ 0.93
XIII	9.1	1.87	11.8	1.88	3.75	55.80 ∓ 1.18	1.59 ∓ 0.018	70.62 ∓ 3.53
XIV	12.2	2.51	3.9	0.62	3.13	52.80 ∓ 1.21	1.48 ∓ 0.023	60.80 ∓ 0.87
XV	12.2	2.51	7.8	1.24	3.75	51.67 ∓ 1.08	1.46 ∓ 0.015	54.47 ∓ 0.36
XVI	15.3	3.15	3.9	0.62	3.77	50.21 ∓ 1.08	1.43 ∓ 0.016	56.88 ∓ 1.55
XVII [a]	0	0	19.6	3.13	3.13	41.96 ∓ 0.82	1.12 ∓ 0.025	11.01 ∓ 0.27
XVIII [b]	9.1	1.87	0	0	1.87	46.54 ∓ 1.11	1.49 ∓ 0.044	37.40 ∓ 0.90

[a] The best culture supplied with sodium nitrate.
[b] The best culture supplied with ammonium sulfate.

TABLE 4

Average data obtained from onion plants grown in Lipa clay loam in pots (4 plants per pot) supplied with different fertilizer mixtures of ammonium sulfate and sodium nitrate (Experiment from November 10, 1939, to March 31, 1940)

CULTURE NO.	AMMONIUM SULFATE		SODIUM NITRATE		TOTAL AMOUNT OF NITROGEN	HEIGHT OF PLANT	DRY WEIGHT OF LEAVES	FRESH WEIGHT OF BULBS
	Amount used	N content	Amount used	N content				
	grams	*grams*	*grams*	*grams*	*grams*	*cm.*	*grams*	*grams*
I	0	0	0	0	0	24.63 ∓ 0.71	0.18 ∓ 0.008	4.32 ∓ 0.42
II	3.0	0.61	3.9	0.62	1.23	47.01 ∓ 1.07	1.04 ∓ 0.014	39.98 ∓ 3.37
III	3.0	0.61	7.8	1.24	1.85	46.82 ∓ 0.77	1.33 ∓ 0.040	41.57 ∓ 4.16
IV	3.0	0.61	11.8	1.88	2.49	48.13 ∓ 0.94	1.53 ∓ 0.035	43.17 ∓ 5.28
V	3.0	0.61	15.7	2.51	3.12	46.43 ∓ 1.08	1.33 ∓ 0.022	50.28 ∓ 3.87
VI	3.0	0.61	19.6	3.13	3.74	49.25 ∓ 0.51	1.45 ∓ 0.021	50.88 ∓ 2.37
VII	6.1	1.23	3.9	0.62	1.85	50.42 ∓ 0.59	1.44 ∓ 0.023	56.88 ∓ 6.46
VIII	6.1	1.23	7.8	1.24	2.47	48.37 ∓ 0.53	1.40 ∓ 0.009	52.57 ∓ 4.95
IX	6.1	1.23	11.8	1.88	3.11	49.55 ∓ 0.46	1.48 ∓ 0.029	51.47 ∓ 5.71
X	6.1	1.23	15.7	2.51	3.74	51.06 ∓ 0.43	1.51 ∓ 0.009	66.22 ∓ 6.12
XI	9.1	1.87	3.9	0.62	2.49	51.38 ∓ 1.46	1.53 ∓ 0.012	65.12 ∓ 7.44
XII	9.1	1.87	7.8	1.24	3.11	51.92 ∓ 0.64	1.54 ∓ 0.022	74.82 ∓ 5.81
XIII	9.1	1.87	11.8	1.88	3.75	57.86 ∓ 1.18	1.77 ∓ 0.009	94.81 ∓ 1.23
XIV	12.2	2.51	3.9	0.62	3.13	54.68 ∓ 1.07	1.62 ∓ 0.029	93.22 ∓ 4.69
XV	12.2	2.51	7.8	1.24	3.75	52.23 ∓ 0.92	1.54 ∓ 0.017	72.27 ∓ 5.08
XVI	15.3	3.15	3.9	0.62	3.77	50.83 ∓ 0.39	1.53 ∓ 0.011	65.63 ∓ 0.13
XVII [a]	0	0	19.6	3.13	3.13	42.56 ∓ 0.78	1.17 ∓ 0.016	29.44 ∓ 2.80
XVIII [b]	9.1	1.87	0	0	1.87	51.01 ∓ 0.62	1.64 ∓ 0.073	53.11 ∓ 1.29

[a] The best culture supplied with sodium nitrate.
[b] The best culture supplied with ammonium sulfate.

TABLE 5

Average data obtained from onion plants grown in Lipa clay loam in pots (1 plant per pot) supplied with best mixture of ammonium sulfate and sodium nitrate plus the kryptotrophic elements (Experiment from November 26, 1939, to April 7, 1940)

CULTURE NO.	SECONDARY ELEMENTS USED AND AMOUNT APPLIED		HEIGHT OF PLANT	DRY WEIGHT OF LEAVES	FRESH WEIGHT OF BULBS
		gram	*cm.*	*grams*	*grams*
I	None	0	25.62 ∓ 1.09	0.24 ∓ 0.008	4.90 ∓ 0.89
II	None	0	51.88 ∓ 0.97	1.50 ∓ 0.028	53.08 ∓ 5.60
III	Manganese	0.05	53.82 ∓ 0.49	1.48 ∓ 0.029	97.02 ∓ 6.36
IV	Manganese	0.1	54.25 ∓ 1.11	1.57 ∓ 0.052	106.90 ∓ 14.44
V	Manganese	0.2	55.57 ∓ 0.31	1.62 ∓ 0.032	112.20 ∓ 4.50
VI	Manganese	0.3	58.77 ∓ 0.46	1.65 ∓ 0.039	138.50 ∓ 8.26
VII	Manganese	0.4	49.75 ∓ 1.22	1.49 ∓ 0.008	94.87 ∓ 10.86
VIII	Boron	0.05	56.60 ∓ 0.60	1.51 ∓ 0.017	91.85 ∓ 13.65
IX	Boron	0.1	53.02 ∓ 0.66	1.62 ∓ 0.033	115.62 ∓ 18.00
X	Boron	0.2	58.52 ∓ 0.47	1.81 ∓ 0.027	119.22 ∓ 19.21
XI	Boron	0.3	61.27 ∓ 0.31	1.85 ∓ 0.031	155.17 ∓ 5.45
XII	Boron	0.4	55.20 ∓ 0.37	1.65 ∓ 0.058	96.85 ∓ 17.03
Ia	None	0	25.62 ∓ 1.09	0.24 ∓ 0.008	4.90 ∓ 0.89
IIa	None	0	51.88 ∓ 0.97	1.50 ∓ 0.028	53.08 ∓ 5.60
IIIa	Zinc	0.05	56.72 ∓ 0.42	1.81 ∓ 0.008	149.02 ∓ 7.50
IVa	Zinc	0.1	60.70 ∓ 0.30	1.91 ∓ 0.014	172.12 ∓ 6.65
Va	Zinc	0.2	52.50 ∓ 0.41	1.78 ∓ 0.010	141.37 ∓ 10.92
VIa	Zinc	0.3	52.65 ∓ 0.20	1.75 ∓ 0.023	101.97 ∓ 20.80
VIIa	Zinc	0.4	48.57 ∓ 1.09	1.53 ∓ 0.032	90.35 ∓ 10.25
VIIIa	Copper	0.05	50.50 ∓ 0.36	1.55 ∓ 0.030	95.30 ∓ 8.71
IXa	Copper	0.1	53.35 ∓ 0.65	1.77 ∓ 0.041	126.56 ∓ 8.65
Xa	Copper	0.2	56.77 ∓ 0.56	1.82 ∓ 0.020	156.75 ∓ 14.88
XIa	Copper	0.3	52.62 ∓ 0.83	1.53 ∓ 0.029	94.60 ∓ 9.77
XIIa	Copper	0.4	48.12 ∓ 0.85	1.47 ∓ 0.028	74.57 ∓ 9.43

TABLE 6

Average data obtained from onion plants grown in Lipa clay loam in pots (1 plant per pot) supplied with best mixtures of ammonium sulfate and sodium nitrate plus the best kryptotrophic elements and the combination of Mn and B; Mn, B, and Zn; and Mn, B, Zn, and Cu (Experiment from December 16, 1939, to April 27, 1940)

CULTURE NO.	SECONDARY ELEMENTS USED AND AMOUNT APPLIED	HEIGHT OF PLANT	DRY WEIGHT OF LEAVES	FRESH WEIGHT OF BULBS
	gram	*cm.*	*grams*	*grams*
I	None 0	23.62 ∓ 0.54	0.19 ∓ 0.005	6.52 ∓ 1.46
II	None 0	50.37 ∓ 0.65	1.44 ∓ 0.018	73.25 ∓ 3.53
III	Manganese 0.3	51.10 ∓ 0.53	1.52 ∓ 0.011	104.95 ∓ 4.21
IV	Boron 0.3	51.55 ∓ 0.54	1.56 ∓ 0.010	111.07 ∓ 4.41
V	Zinc 0.1	52.25 ∓ 0.38	1.58 ∓ 0.018	129.55 ∓ 9.23
VI	Copper 0.2	51.60 ∓ 0.56	1.57 ∓ 0.012	121.40 ∓ 10.57
VII	Mn and B ..... 0.3 + 0.3	55.60 ∓ 1.73	1.67 ∓ 0.010	132.27 ∓ 23.14
VIII	Mn, B, and Zn ..... 0.3 + 0.3 + 0.1	56.57 ∓ 1.12	1.82 ∓ 0.007	132.57 ∓ 13.08
IX	Mn, B, Zn, and Cu .... 0.3 + 0.3 + 0.1 + 0.2	55.90 ∓ 1.36	1.69 ∓ 0.007	130.10 ∓ 15.65

THE NORMAL FEED CONSUMPTION OF LOS BAÑOS CANTONESE CHICKS[1]

NICANOR L. LOSBAÑES

These studies were conducted in the Department of Animal Husbandry from November, 1936, to July, 1938, to determine (*a*) the amount of feed that chicks will need at different ages and (*b*) the effects of free-choice feeding and self-feeding of mash on the feed consumption and the rate of growth of chicks.

Amon (1930) found that one hundred Los Baños Cantonese chicks fed with equal amounts of mash and grain consumed 210.5 kilograms, while a similar number given their feed free-choice consumed 221.4 kilograms from hatching to twelve weeks of age. In a recent study in which the chicks were raised indoors and self-fed with mash containing shrimp meal, ground corn, and rice bran, Ragat (1939) reported that 170.06 kilograms were needed to raise one hundred Los Baños Cantonese chicks from hatching to twelve weeks of age.

PLAN OF THE STUDY

A total of 332 Los Baños Cantonese chicks that were artificially hatched from eggs of the College flocks were used in this study. Three sets of observations of two lots each were made, each covering a period of twelve weeks. There were 58 chicks to a lot, in the first set, 66 in the second, and 42 in the third, thus totalling 166 chicks to a lot.

The feeds used in the experiment were rice bran, ground corn, and shrimp meal. In lot I (free-choice) the ingredients were given separately in three containers. In lot II (mash) the ingredients were mixed and given in the proportion by weight of 55 parts rice bran, 25 parts ground corn, and 20 parts shrimp meal. The chicks had free access to the feed and the drinking water.

The chicks were raised in fireless brooders and each lot was placed in a portable brooding house on a grassy range. The chicks were weighed individually soon after they were removed from the incubator and every week thereafter for twelve weeks. The amount

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[1] Experiment Station contribution No. 1408. Prepared in the Department of Animal Husbandry under the direction of Associate Professor F. M. Fronda.

of feeds consumed was recorded. In lot I the weights of each ingredient consumed were kept separately. Mortality of the chicks was likewise recorded.

RESULTS AND DISCUSSION

Feeds consumed. Table 1 shows that after the first week the chicks in lot I (free-choice) generally consumed more feed than those in lot II (self-fed with mash). On the basis of 100 chicks at the start, the feed consumption in lot I was 205.89 kilograms for the twelve weeks of the experiment, whereas that of lot II was 188.48 kilograms for the same period. In a free-choice feeding experiment involving the feeding of ground palay and copra meal in addition to shrimp meal, ground corn, and rice bran as used in the present study, Amon (1930) found that 100 chicks consumed 221.4 kilograms of feed for twelve weeks and those fed with mash and grain in equal proportion consumed 142.5 kilograms for the same length of time.

The relative proportions of the different ingredients consumed every week in lot I are presented in table 2. Consistently, for twelve weeks, ground corn was the most palatable. The rate of consumption of shrimp meal was slightly lower than that of rice bran. In three months, 100 chicks consumed on the average 27.1 per cent of shrimp meal, 40.6 of ground corn, and 32.3 per cent of rice bran.

Growth of chicks. The weekly weights of the chicks were used as a measure for determining the effect of the two systems of feeding on the rate of growth (table 3). From this table it may be seen that the chicks in each lot weighed about the same at the beginning of the experiment. There was an appreciable variation in the rate of growth of the chicks in both lots during the entire period of observation. The chicks in lot I were consistently lighter than those in lot II. The difference in the weights of the chicks in the two lots was significant for the whole period. The growth of the free-choice lot chicks in this study was quite different from that of Single Comb White Leghorn chicks, which Funk (1932) reported as having obtained normal growth.

The weanlings in lot I weighed 504.5 $\pm$ 8.095 grams whereas those in lot II weighed 546.1 $\pm$ 7.511 grams. The chicks in the free-choice lot of the present study were heavier than those in a similar lot reported by Amon (1930) as having a mean weight of only 417.5 grams. The chicks produced in lot II were about as

heavy as those reported by Savella (1935) and by Ragat (1939) in which the chicks received similar treatment. On the other hand, the chicks in this lot were much lighter than those that were fed with 25 per cent shrimp meal supplement in the ration which Fronda and Kabigting (1934) reported to have weighed 702.2 grams. This may be expected inasmuch as the shrimp meal supplement used in this study was only 20 per cent.

The chicks in lot II were observed to be more uniform in size and to have feathered earlier than those in lot I, although they were similarly active and vigorous. Among the cockerels, the combs and the wattles were more developed in lot II than in lot I.

Mortality of the chicks. Table 4 gives the percentage mortality of the chicks in each lot. Lot I had an average mortality of 36.52 ± 1.084 per cent as against 24.49 ± 2.496 in lot II, the difference being statistically significant. There was heavy mortality in lot I during the first five weeks, while in lot II mortality was observed to be more or less uniformly distributed during the first ten weeks and absent during the last two weeks of the experiment. In both lots death was mostly due to cold.

Cost of production. Assuming that one hundred chicks were used in each lot at the start, the feed cost to raise them to twelve weeks of age is given in table 5. It may be noted that based upon the price of feeds prevailing during the duration of the experiment, the chicks in lot I consumed 205.89 kilograms of feeds valued at ₱12.48, whereas those in lot II consumed 188.48 kilograms valued at ₱10.67, a difference of ₱1.81 in favor of the latter. The returns above cost of feed were computed by subtracting the cost of feed from the value of weanlings produced from one hundred chicks at ₱0.60 a kilogram liveweight. In lot I this was ₱6.47, whereas in lot II it was ₱14.08, or ₱7.28 more.

SUMMARY AND CONCLUSIONS

1. It needed 205.89 kilograms of feed valued at ₱12.48 to raise one hundred Los Baños Cantonese chicks to weaning age by the free-choice method, whereas those that were self-fed with mash required only 188.48 kilograms valued at ₱10.61.

2. The mash-fed chicks were consistently heavier than the free-choice fed chicks.

3. A lower mortality was observed among the mash-fed chicks than among the free-choice fed chicks, i.e., 24.47 ± 2.496 versus 36.52 ± 1.084 per cent.

LITERATURE CITED

AMON, VALENTIN. 1930. Studies on the influence of free choice of feeds in the poultry feeding. The Philippine Agriculturist **19**: 445–449.

FRONDA, F. M., AND A. KABIGTING. 1934. Protein supplement in poultry ration: III. The optimum amount of shrimp meal to use as supplement in ration for growing chicks. The Philippine Agriculturist **23**: 652–661.

FUNK, E. M. 1932. Can the chick balance its ration? Poultry Sci. **11**: 94–97.

RAGAT, MODESTO. 1939. A comparative study of chicks raised indoors and outdoors. The Philippine Agriculturist **28**: 593–600.

SAVELLA, S. H. 1935. A comparative study of various methods of feeding chicks. The Philippine Agriculturist **25**: 452–459.

TABLE 1

Mean weekly feed consumption based on 100 chicks at the start

AGE OF CHICKS	LOT I FREE-CHOICE	LOT II MASH
weeks	*kgm.*	*kgm.*
1	5.25	5.30
2	8.02	6.68
3	9.11	7.35
4	10.50	11.20
5	13.43	13.28
6	17.34	16.20
7	19.28	17.78
8	22.47	19.15
9	23.13	20.06
10	26.89	21.25
11	25.65	23.85
12	24.82	26.38
Total ...	205.89	188.48

TABLE 2

Proportion of the different ingredients in the feed consumed by the chicks in lot I at different ages

AGE OF CHICKS	SHRIMP MEAL	GROUND CORN	RICE BRAN
weeks	*per cent*	*per cent*	*per cent*
1	22.8	46.8	30.4
2	24.8	41.6	33.6
3	25.0	42.6	32.4
4	30.5	41.5	28.0
5	35.4	37.7	26.9
6	30.8	37.3	31.9
7	27.9	40.5	31.6
8	23.2	38.1	38.7
9	20.9	42.2	36.9
10	24.4	40.5	35.1
11	25.2	43.4	31.4
12	34.6	34.7	30.7
Average ...	27.1	40.6	32.3

TABLE 3

Mean weekly weights of the chicks in the two lots for twelve weeks

AGE OF CHICKS	LOT I		LOT II	
	No. of chicks	Mean weights	No. of chicks	Mean weights
		grams		*grams*
1 day	166	25.7 ± 0.170	166	25.4 ± 0.150
1 week	147	31.1 ± 0.191	154	32.6 ± 0.234
2 weeks	141	42.7 ± 0.376	146	46.5 ± 0.491
3 "	131	61.6 ± 0.589	146	62.9 ± 0.686
4 "	119	76.3 ± 1.132	142	83.7 ± 1.045
5 "	114	118.6 ± 1.758	134	131.3 ± 1.793
6 "	111	156.3 ± 2.690	124	166.8 ± 2.700
7 "	106	187.8 ± 3.539	123	216.6 ± 3.682
8 "	101	257.5 ± 4.237	118	277.4 ± 4.101
9 "	95	324.5 ± 5.850	115	355.2 ± 5.209
10 "	91	385.0 ± 6.270	108	407.6 ± 6.231
11 "	88	461.7 ± 7.001	104	482.9 ± 7.231
12 "	86	504.5 ± 8.095	104	546.1 ± 7.511

TABLE 4

Mortality of chicks during the twelve weeks of brooding[a]

LOT NO.	SET			AVERAGE
	1ST	2ND	3RD	
	per cent	*per cent*	*per cent*	*per cent*
I	34.48	39.39	35.71	36.52 ± 1.084
II	20.68	24.24	28.57	24.49 ± 2.496

[a] The chicks that were lost accidentally were not counted as lost owing to normal death.

TABLE 5

Returns above cost of feed based on 100 chicks at the start

ITEMS	LOT I FREE-CHOICE	LOT II MASH
Number of chicks	100	100
Number of weanlings raised	63	75
Average weight, kgm.	0.51	0.55
Total weight, kgm.	32.13	41.25
Value in pesos of weanlings at 60 centavos a kgm.	19.28	24.75
Amount of feed consumed, kgm...	205.89	188.48
Cost of feed consumed in pesos ..	12.48	10.67
Returns above cost of feed in pesos	6.80	14.08

STUDIES ON THE FERTILIZING VALUE OF MAYON VOLCANO ASH: III. EFFECTS UPON GROWTH, DEVELOPMENT, AND YIELD OF UPLAND RICE[1]

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No doubt the lava and ashes that Mayon Volcano emitted during its eruption in June, 1938, have somewhat modified the physical and chemical composition of the soils on some farms in Albay. Although Abella y Casariego (1882), Coronas (1898), and Smith (1924), as cited by Galvez (1939), showed interest in this volcano and its occasional activity, none of them attempted to determine the agricultural value of the lava and ashes.

The first investigator to report on the agricultural value of the Mayon Volcano ash was Sherman (1929). Reports of a similar kind were made a few years later by Espino (1939 a, b). Galvez (1939), and Galvez, Aquino, and Mamisao (1939).

Review of literature

Sherman (1929) found that the Mayon Volcano ash was acidic and that it contained potential nutrient elements for abacá, namely, nitrogen, potash, and phosphoric acid.

Galvez (1939) also found that the fine ejecta of Mayon Volcano contained all the chief constituents of rocks, namely, SiO_2, TiO_2, Al_2O_3, Fe_2O_3, Mn_3O_4, CaO, MgO, K_2O, Na_2O, and P_2O_5, and that the texture was similar to that of loam soils. He observed that different plants growing near the volcano varied in their ability to stand the eruption. He noticed that abacá and papaya appeared very sensitive, whereas coconut, coffee, banana, gabi, and rice appeared not adversely affected at all. He noted that plants having soft, tender, and hairy leaves suffered more than those with thick, hard, glossy ones.

By chemical analyses, Galvez, Aquino, and Mamisao (1939) found that the volcanic ash contained all the inorganic constituents generally present in ordinary agricultural soils, except nitrogen; and, with the exception of CaO, its fertilizing constituents, like K_2O

[1] Experiment Station contribution No. 1409.

and P_2O_5, were no more abundant than those present in the ordinary soils. They noted that the volcanic ash contained less available potash and more available phosphoric acid than the soil in Albay.

Espino (1939a) observed that large applications of the volcanic ash were harmful to the young corn, radish, and rice plants, but not to the young soybean plants. The affected plants were stunted in growth and had chlorotic leaves; this was attributed either to the production of a physiologically unbalanced solution or to the formation of a compact medium which was poorly drained and inadequately aërated.

Espino (1939b) made further pot culture experiments and found that the harmful effect of the liberal application of volcanic ash upon rice, corn, and radish disappeared with the addition of ammonium sulfate to the culture, and that the plants that were supplied both with the volcanic ash and ammonium sulfate were healthier and better developed than those grown in Lipa clay loam either alone or with ammoium sulfate. Hence, he concluded that not the compactness of the soil in the culture media but rather the production of a physiologically unbalanced solution in the culture media was the real cause.

Owing to the smallness of the pots used, Espino did not allow his plants to reach maturity.

Objects of this study

The objects of this study were: (*a*) to determine whether or not ashes from Mayon Volcano when added to Lipa clay loam would affect not only the growth and development but also the yield of upland rice, (*b*) to determine the amount of volcanic ash most beneficial to rice plants, and (*c*) to find out what single fertilizer should be added to the volcanic ash to obtain a mixture beneficial to upland rice plants when grown in Lipa clay loam.

Time and place of this study

This study was conducted in the experimental yard of the Department of Agricultural Botany from August, 1938, to October, 1939.

MATERIALS AND METHODS

Plants

Seeds of upland rice, variety Inintiw, were soaked in water for twenty-four hours and germinated for five days in moist sand. The

young plants were transplanted to the pots, four plants to each. When two weeks old, the two least healthy seedlings in each pot were pulled up.

Soil

The soil used was Lipa clay loam. It was taken from a lot behind the Administration Building and near the U. P. Rural High School Reservation. The soil was sifted and thoroughly mixed before being used. About seventeen kilograms were placed in each can, which had a surface area of 23 × 23 centimeters and a depth of 35 centimeters.

Mayon ash

The Mayon ash was collected from Albay in 1938 by Dr. Nicolas Galvez of the Department of Soils. It was from the same lot where Galvez (1939), Galvez, Aquino, and Mamisao (1939), and Espino (1939a, b) got their volcanic ash for their studies. Before being used, the ash was allowed to dry in the room, mixed thoroughly, and the required amounts were weighed out separately.

Galvez (1939) reported that the volcanic ash contained 0.55 per cent P_2O_5, 1.16 per cent K_2O, and 8.50 per cent CaO, aside from other mineral constituents. Galvez, Mamisao, and Aquino (1939) found no nitrogen in the ash.

Culture media

Five main sets of cultures were tried; four sets of these were each run once more making nine sets of cultures in all. In these, aside from the Mayon Volcano ash, three commercial fertilizers were employed. They were ammonium sulfate containing 20.6 per cent N, single superphosphate with 18 to 20 per cent P_2O_5, and potassium sulfate with 48 to 50 per cent K_2O. These fertilizers were applied at the time of planting.

Mayon Volcano ash in moderate amounts. The first set was composed of nine cultures supplied with relatively small amounts of Mayon Volcano ash. Culture I received no Mayon Volcano ash; II, 1.32 grams; III, 2.64 grams; IV, 3.96 grams; V, 5.28 grams; VI, 6.60 grams; VII, 7.92 grams; VIII, 9.24 grams; and IX, 10.56 grams. Each culture was run in triplicate.

Mayon Volcano ash in liberal amounts. The second set consisted of six cultures supplied with varying liberal amounts of Mayon Volcano ash. Culture I received no Mayon Volcano ash; II,

400 grams per pot or enough to cover the surface one-half centimeter deep; III, 800 grams, or one centimeter deep; IV, 1,200 grams, or one and one-half centimeters deep; V, 1,600 grams, or two centimeters deep, and VI, 2,000 grams or two and one-half centimeters deep. The ash was mixed thoroughly with the 17 kilograms of soil, simulating the effects of plowing and harrowing in the field. Each culture was run in quadruplicate.

Mayon Volcano ash and ammonium sulfate. The third set was composed of seven cultures, each of which was run in quadruplicate. With the exception of cultures I and II, all were supplied with varying liberal amounts of Mayon ash and 6 grams of ammonium sulfate each. Culture I contained only Lipa clay loam; II, only 6 grams ammonium sulfate; III, 400 grams ash; IV, 800 grams; V, 1,200 grams; VI, 1,600 grams; and VII, 2,000 grams of volcanic ash. Cultures III to VII, inclusive, each received 6 grams of ammonium sulfate.

Mayon Volcano ash and superphosphate. The procedure with the fourth set was similar to that of the Mayon ash and ammonium sulfate set. It was composed of seven cultures; each was run in quadruplicate. Culture I contained the soil only; II received no Mayon ash; III, 400 grams; IV, 800 grams; V, 1,200 grams; VI, 1,600 grams; and VII, 2,000 grams of volcanic ash. Each of the cultures from II to VII inclusive received 6 grams of superphosphate.

Mayon Volcano ash and potassium sulfate. The fifth set consisted of seven quadruplicated cultures, and with the exception of cultures I and II, they were supplied with liberal amounts of the volcanic ash and the same amounts of potassium sulfate. Culture I received soil alone; II, only 6 grams potassium sulfate; III, 400 grams of Mayon ash; IV, 800 grams; V, 1,200 grams; VI, 1,600 grams; and VII, 2,000 grams. Cultures III to VII inclusive each received 6 grams of potassium sulfate.

EXPERIMENTS AND RESULTS

The cultures

Mayon Volcano ash in moderate amounts. This set of cultures was conducted with the object of determining the effects upon the growth and yield of rice plants when added to Lipa clay loam only in moderate amounts. The cultures were started on August 15, 1938, and harvested on December 6, 1938. The experimental data obtained are recorded as averages in table 1.

Mayon Volcano ash in liberal amounts. Since, as seen from the preceding cultures, the addition of moderate amounts of the volcanic ash to Lipa clay loam had not markedly influenced the growth and yield of rice one way or another, more liberal amounts of the ash were tried. Moreover, Espino (1939a) had observed that liberal amounts of the ash when added to Lipa clay loam were always harmful to young rice plants. Whether the plants would recover or not on reaching maturity remained to be seen—hence, this set of cultures.

The first set of cultures was started on January 21, 1939, and on April 29, 1939, the cultures were harvested. The experimental data obtained are given as averages in table 2. This set was run again from July 15, 1939, to October 25, 1939 (table 2).

Mayon Volcano ash and ammonium sulfate. From the culture studies made by Espino (1939b), it was revealed that when the Mayon ash was added in liberal amounts to Lipa clay loam, a soil poor in nitrogen, the young rice plants produced were always stunted in growth and chlorotic. Upon addition of ammonium sulfate, however, a much better growth was obtained. Whether or not these same plants would give high yields of grains remained to be seen—hence, these cultures.

This set of cultures was run twice. The first was from January 21, 1939, to April 29, 1939, and the second, from July 15, 1939, to October 25, 1939; on maturity of the grains, the cultures were harvested (table 3).

Mayon Volcano ash and superphosphate. This set of cultures was also tried twice. The first set was started on January 21, 1939, and harvested on April 29, 1939. The experimental data obtained are recorded as averages in table 4.

The second set of cultures was conducted from July 15, 1939, to October 25, 1939. The experimental data obtained are also in table 4.

Mayon Volcano ash and potassium sulfate. This set of cultures was also tried twice. The first set was run from January 21, 1939, to April 29, 1939, and the second set, from July 15, 1939, to October 25, 1939. The experimental data obtained from the two sets are given in table 5.

Care of cultures

The cultures in each set were exposed to light and rain and were always kept moist. They were watered from time to time whenever

necessary. Also they were weeded and cultivated whenever necessary.

Criteria of results

Height of plants. The data on height of plants were taken at the time of harvest. Measurements were made from the base of the culms to the tip of the tallest leaf in each culture. The data obtained from similar cultures were averaged.

Number of tillers. The culms of the two plants in each pot were counted at the time of harvest. The average data were obtained by adding together the number of culms in similar cultures, and the sum was divided by the number of replications.

Sun-dried weight of tops. After the panicles had been harvested, the straw from each culture was cut close to the roots, bundled, and labeled. It was dried in the sun and weighed. The data obtained from the similar cultures were averaged.

Sun-dried weight of grains. The harvested panicles from each culture were placed in a paper bag properly labeled, dried in the sun, and threshed carefully by hand. The grains were weighed, and the data obtained from similar cultures were averaged.

Sun-dried weight of roots. The roots were removed from the pots after the tops had been severed and thoroughly washed with water. Those from each culture or from similar cultures were tied together, wrapped in paper, and labeled. They were then dried in the sun and weighed. The data obtained from similar cultures were averaged.

DISCUSSION OF RESULTS

Effects of moderate amounts of Mayon ash

Table 1 shows that the Mayon ash-treated cultures did not differ much from one another, and were not always consistently better than the culture which received no Mayon Volcano ash at all. The three cultures, II, IV, and VIII, that gave the highest yields of grains, were statistically compared with the control, culture I. The results showed that with the exception of the difference in dry weight of tops between cultures IV and I (which happened to be only slightly significant), none of the arbitrarily selected cultures, II, IV, and VIII, was significantly better than the control.

Table 1 further shows that a few cultures existed with yield values somewhat lower than the corresponding yield values obtained

from the control culture. The differences are so small, however, that they might be considered as insignificant. Therefore, Mayon volcano ash when added to Lipa clay loam at the rates ranging from 1.32 to 10.56 grams per pot was neither beneficial nor harmful to the rice plant.

Effects of liberal amounts of Mayon ash

By liberal amounts are meant rates ranging from 400 to 2,000 grams per pot. Espino (1939a) observed that certain liberal applications of the volcanic ash to Lipa clay loam had proved rather harmful to the young rice plants. In the present study, however, certain yield values obtained from some of the ash-treated cultures were greater than the corresponding ones from the control (table 2). In some respects cultures II and III, which received 400 and 800 grams respectively of the Mayon Volcano ash per pot, and culture IIa, which contained 400 grams of the ash, appeared better than culture I, the control. But when these ash-treated cultures were statistically compared with the corresponding control culture, the differences were insignificant.

In table 2, cultures V and VI and their counterparts, cultures Va and VIa, produced yield values mostly lower than the corresponding yield values obtained from the control cultures. Statistical comparisons of the data obtained from these cultures were made.

Culture V and VI and Va and VIa arbitrarily selected from table 2 received 1600 and 2000 grams of Mayon ash per pot. That heavy applications of Mayon ash to Lipa clay loam were not really harmful to the rice is shown by the fact that although most of the differences were in favor of the control, or the untreated cultures (I and Ia), such differences were statistically insignificant. The significant differences, however, were observed in two comparisons (V-I, and VI-I), and always in favor of the control. It is, therefore, possible for a heavy application of Mayon Volcano ash to Lipa clay loam to affect the rice plant adversely, that is, to produce grains markedly lower than those obtained from the untreated cultures.

Effects of adding ammonium sulfate with Mayon ash

Table 3 shows some differences in yield values. An arbitrary selection of the three highest yield values under each criterion was made. These were indicated by H's. The results showed that cultures III, V, IIIa, and VIIa received the largest number of H's. These

cultures might, therefore, be considered as the best in the two sets of cultures.

In order to determine whether or not this arbitrary selection would be borne out by statistical comparisons, selected cultures were compared with the control. It should be pointed out that in the two sets of cultures (table 3), two kinds of control cultures were employed. Cultures I and Ia, which were similar, received neither Mayon ash nor ammonium sulfate, whereas cultures II and IIa, also similar, received six grams of ammonium sulfate each but no Mayon ash.

In the two sets of cultures, the differences between cultures III and I, IIIa and Ia, and VIIa and Ia were statistically significant. But the differences between III and II, IIIa and IIa, and VIIa and IIa were mostly statistically insignificant. It appears, therefore, that the improvements in growth and in yield of the rice plants were due principally to the ammonium sulfate employed rather than to the liberal amounts of Mayon Volcano ash used. In other words, under the conditions of this experiment, the addition of ammonium sulfate with a liberal amount of Mayon ash to Lipa clay loam neutralized the harmful effects of the ash upon the rice plant, and the Mayon ash itself did not materially contribute benefits to the plant.

Effects of adding superphosphate with Mayon ash

The yield data obtained from the cultures treated with the volcanic ash and superphosphate were so low that they were quite similar to the corresponding data obtained from unfertilized cultures. The ammonium sulfate-treated plants were much taller and larger than the superphosphate-treated ones.

In table 4 are shown the apparently most promising cultures arbitrarily selected from each of the two sets of cultures. These cultures were statistically compared with each of the two control cultures.

The differences between these two supposedly most promising cultures (III and IV) and the control cultures (I and II) are statistically insignificant although some statistically significant differences were also noted. Although some of the differences were in favor of the cultures supplied both with the Mayon Volcano ash and superphosphate, nevertheless, some of the differences were in favor of the cultures supplied only with superphosphate. Therefore, a liberal application of Mayon Volcano ash to Lipa clay loam accompanied with superphosphate may prove either beneficial or harmful to the rice plant.

Effects of adding potassium sulfate with Mayon ash

The experimental data for these two sets of cultures (table 5) showed that not much difference existed between any of the Mayon Volcano ash-treated cultures and any of the two types of control cultures. Therefore, the application of Mayon Volcano ash and potassium sulfate to Lipa clay loam was suspected to be neither appreciably beneficial nor markedly harmful. Evidently this was the case because of all the comparisons made, not a single difference was found statistically significant. More of these negative, or harmful, effects were noted, though in some of them the differences were statistically insignificant.

Therefore, it may be concluded that applications of potassium sulfate and Mayon Volcano ash to Lipa clay loam are sometimes harmful to the rice plant. From such mixtures, no significant beneficial effects upon the plant were noted.

Results of the present study in the light of available literature

The results have shown that the addition of moderate amounts of Mayon Volcano ash was neither beneficial nor harmful to a rice plant. However, liberal applications of the Mayon Volcano ash appeared to have a tendency to become harmful to this plant. This seems to confirm Espino's (1939a, b) observation that certain liberal applications of the volcanic ash to Lipa clay loam proved rather harmful to the young plants. Espino pointed out that the harmful effect was due to the production of a physiologically unbalanced solution in the soil.

The addition of ammonium sulfate to Lipa clay loam supplied with heavy applications of the volcanic ash appeared to have counteracted the harmful effects of the ash on the rice plant. Moreover, the presence of volcanic ash in the soil had not materially contributed benefits to the plant. Espino (1939b) found that the harmful effect of the volcanic ash upon rice disappeared with the addition of ammonium sulfate to the cultures and that the plants supplied with both ammonium sulfate and Mayon Volcano ash were apparently even healthier and better developed than those which grew in Lipa clay loam either alone or with ammonium sulfate. Owing to the smallness of the pots that he used, Espino did not grow his rice to maturity. From the present experiments, therefore, it is of interest to note that the plants supplied with both Mayon ash and ammonium sulfate produced grains that were not significantly more than those which received ammonium sulfate alone.

The application of superphosphate with Mayon ash produced neither beneficial nor harmful effects on rice plants grown in Lipa clay loam. According to the analysis of Galvez (1939), the volcanic ash contained 0.56 per cent P_2O_5. The addition of the ash together with superphosphate naturally increased the P_2O_5 content of the soil. Such an addition may even prove detrimental. Talamisan (1938), however, found that the application of superphosphate to Lipa clay loam, although not harmful, was not necessary for increasing the yield of rice.

The application of Mayon ash and potassium sulfate to Lipa clay loam was neither appreciably beneficial nor markedly harmful to the rice plant. Mayon ash contained large amounts of potash as reported by Galvez (1939). Therefore, the addition of potassium sulfate and Mayon ash increased the potash content of the soil. Lipa clay loam, however, has been found by Enrile (1938) to contain sufficient potash for the rice plant so that an addition of this plant nutrient to the soil is not necessary for increasing the yield of rice. Its addition may even prove detrimental, especially in soils like Lipa clay loam, which is poor in nitrogen (Espino, 1939b).

SUMMARY AND CONCLUSIONS

From the results of this study the following conclusions may be drawn:

1. Mayon Volcano ash when added to Lipa clay loam at the rates ranging from 1.32 to 10.56 grams per pot was neither beneficial nor harmful to the rice plant.

2. A heavy application of the Mayon ash to Lipa clay loam affected the rice plant adversely, producing fewer grains than were obtained from untreated plants.

3. The improvements in growth and yield of the rice plants supplied with both Mayon ash and ammonium sulfate appeared to be due principally to the ammonium sulfate used rather than to the liberal amounts of Mayon Volcano ash.

4. The addition of ammonium sulfate to Lipa clay loam containing liberal amounts of Mayon Volcano ash counteracted the harmful effects of the ash on the rice plant, and the Mayon Volcano ash itself did not materially contribute benefits to the rice plant.

5. A liberal application of Mayon Volcano ash with superphosphate to Lipa clay loam was neither consistently beneficial nor harmful to the rice plant.

6. The application of Mayon ash and potassium sulfate to Lipa clay loam was also neither consistently beneficial nor markedly harmful to the rice plant, and such treatments tended to be more harmful than beneficial.

LITERATURE CITED

ENRILE, PABLO C. 1938. Should potassium sulfate be added with ammonium sulfate to Lipa clay loam for upland rice? The Philippine Agriculturist **27**: 148–167.

ESPIÑO, RAFAEL B. 1939a. Studies on the fertilizing value of Mayon Volcano ash: I. Effects upon plants of liberal application of volcanic ash. The Philippine Agriculturist **28**: 133–142.

ESPIÑO, RAFAEL B. 1939b. Studies on the fertilizing value of Mayon Volcano ash: II. Beneficial effects of adding ammonium sulfate. The Philippine Agriculturist **28**: 260–267.

GALVEZ, NICOLAS L. 1939. The chemical and physical compositions of the fine ejecta of Mayon Volcano. The Philippine Agriculturist **27**: 765–771.

GALVEZ, N. L., D. I. AQUINO, AND J. P. MAMISAO. 1939. Agricultural value of the fine ejecta of Mayon Volcano. The Philippine Agriculturist **27**: 844–854.

SHERMAN, HARTLEY EMBREY. 1929. Volcanic dust from Mayon and its effect upon the surrounding abacá district. Philippine Agric. Rev. **22**: 39–41.

TALAMISAN, BENIGNO G. 1938. Should superphosphate be added with ammonium sulfate to Lipa clay loam for upland rice? The Philippine Agriculturist **27**: 284–309.

TABLE 1

Average data obtained from cultures of upland rice in pots of Lipa clay loam supplied with relatively small amounts of Mayon Volcano ash

(Experiment from August 29, 1938, to December 6, 1938)

CULTURE NO.	AMOUNT OF MAYON ASH USED	HEIGHT OF PLANTS	NUMBER OF TILLERS	DRY WEIGHT OF		
				Tops	Grains	Roots
	grams	*cm.*		*grams*	*grams*	*grams*
I	0 (control)	79.7	7.0	8.47	11.83	4.13
II	1.32	79.3	6.3	10.18	12.17	4.28
III	2.64	72.9	6.3	8.62	9.15	4.73
IV	3.96	78.0	7.3	10.43	12.55	4.63
V	5.28	83.1	6.3	10.20	12.10	4.05
VI	6.60	71.8	7.7	9.25	9.43	5.17
VII	7.92	78.6	6.3	9.08	11.35	3.35
VIII	9.24	75.5	7.3	10.03	12.28	4.73
IX	10.56	77.6	8.0	9.92	11.57	5.17

TABLE 2

Average data obtained from cultures of upland rice in pots of Lipa clay loam supplied with relatively large amounts of Mayon Volcano ash

(Experiment, from January 21, 1939, to April 29, 1939)

CULTURE NO.	AMOUNTS OF MAYON ASH ADDED	HEIGHT OF PLANTS	NUMBER OF TILLERS	DRY WEIGHT OF		
				Tops	Grains	Roots
	grams	*cm.*		*grams*	*grams*	*grams*
I	0	75.9	9.0H	14.80H	9.65H	5.77
II	400	79.4 H	8.8	13.38	8.68H	7.20H
III	800	77.0 H	12.0H	15.48H	7.19H	7.69H
IV	1,200	74.0	10.0H	14.23	6.73	8.20H
V	1,600	77.2 H	8.3	15.19H	7.06	6.00
VI	2,000	75.8	7.5	12.59	6.79	4.48

(Experiment, from July 15, 1939, to October 25, 1939)

Ia	0	115.80H	14.5H	29.99	31.55H	12.22H
IIa	400	116.40H	14.0H	32.50H	31.79H	10.50H
IIIa	800	113.80	12.5	30.83H	30.44	10.00
IVa	1,200	116.90H	13.72 [a]	31.96H [a]	32.50H [a]	11.40H [a]
Va	1,600	115.10	12.0	27.78	29.22	7.75
VIa	2,000	108.70	15.0H	29.63	29.25	9.12

[a] Computed because one plant died; not included in discussion of results.

TABLE 3

Average harvest data obtained from cultures of upland rice grown in pots of Lipa clay loam supplied with relatively large amounts of Mayon Volcano ash and ammonium sulfate

(Experiment, from January 21, 1939, to April 29, 1939)

CULTURE NO.	TREATMENT GIVEN		HEIGHT OF PLANTS	NUMBER OF TILLERS	DRY WEIGHT OF		
	Mayon ash	Ammonium sulfate			Tops	Grains	Roots
	grams	*grams*	*cm.*		*grams*	*grams*	*grams*
I	0	0	75.9	9.0	14.80	9.65	5.77
II	0	6.0	111.80	29.3	60.64	48.12	19.80
III	400.0	6.0	117.8 H	30.5	65.74H	57.20H	26.85H
IV	800.0	6.0	110.1	33.2H	58.20	48.99H	22.43
V	1200.0	6.0	113.9 H	32.0H [a]	68.80H [a]	48.60H [a]	25.46H [a]
VI	1600.0	6.0	112.9 H	28.8	61.70	42.36	23.67
VII	2000.0	6.0	109.5	35.3H	64.19H	46.27	31.84H

(Experiment, from July 15, 1939, to October 25, 1939)

Ia	0	0	115.80	14.5	29.99	31.55	12.22
IIa	0	6.0	116.00	20.0	54.50	39.42H	19.47
IIIa	400.0	6.0	120.80H	25.6H [a]	62.90H [a]	52.70H [a]	23.86H [a]
IVa	800.0	6.0	122.50H	16.8	59.42	34.55	25.00H
Va	1200.0	6.0	118.60	20.0 [a]	57.92 [a]	38.52 [a]	18.42 [a]
VIa	1600.0	6.0	119.40	21.2H	64.70H	38.15	20.50
VIIa	2000.0	6.0	122.10H	22.5H	61.95H	44.81H	23.37H

[a] Computed.

TABLE 4

Average harvest data obtained from cultures of upland rice grown in pots of Lipa clay loam supplied with relatively large amounts of Mayon Volcano ash and superphosphate

(Experiment, from January 21, 1939, to April 29, 1939)

CULTURE NO.	TREATMENT GIVEN		HEIGHT OF PLANTS	NUMBER OF TILLERS	DRY WEIGHT OF		
	Mayon ash	Superphosphate			Tops	Grains	Roots
	grams	*grams*	*cm.*		*grams*	*grams*	*grams*
I	0	0	75.9	9.0 H	14.80H	9.65	5.77
II	0	6.0	77.8 H	8.8 H	14.08H	11.50H	6.65H
III	400.0	6.0	74.4	8.6 [a]	13.25	11.43H	6.65H
IV	800.0	6.0	79.7 H	8.8 H	14.77H	9.85	6.09
V	1200.0	6.0	74.3	7.3	12.67	11.09H	5.20
VI	1600.0	6.0	76.4 H	7.3	11.99	8.26	4.14
VII	2000.0	6.0	72.9	8.0	13.10	9.56	6.52H

(Experiment, from July 15, 1939, to October 25, 1939)

Ia	0	0	115.80H	14.50	29.99	31.55H	12.22H
IIa	0	6.0	107.90H	11.70 [a]	26.00 [a]	24.20 [a]	11.42 [a]
IIIa	400.0	6.0	106.87	16.00H [a]	36.00H [a]	26.30 [a]	13.32H [a]
IVa	800.0	6.0	109.25H	11.50	30.00	20.08	11.12
Va	1200.0	6.0	107.62	17.10H [a]	43.80H [a]	31.14H [a]	18.00H
VIa	1600.0	6.0	101.75	16.00H	31.90H	26.31	11.42
VIIa	2000.0	6.0	107.67	13.30	29.67	27.50H	11.37

[a] Computed.

TABLE 5

Average harvest data obtained from cultures of upland rice grown in pots of Lipa clay loam supplied with relatively large amounts of Mayon Volcano ash and potassium sulfate

(Experiment, from January 21, 1939, to April 29, 1939)

CULTURE NO.	TREATMENT GIVEN		HEIGHT OF PLANTS	NUMBER OF TILLERS	DRY WEIGHT OF		
	Mayon ash	Potassium sulfate			Tops	Grains	Roots
	grams	*grams*	*cm.*		*grams*	*grams*	*grams*
I	0	0	79.5 H	9.0 H	14.80H	9.65H	5.77
II	0	6.0	81.9 H	6.3	13.63	9.67H	4.51
III	400.0	6.0	82.0 H	7.5	13.45	9.40H	5.07
IV	800.0	6.0	78.8	8.5 H	13.68	8.34	5.76
V	1200.0	6.0	79.4	7.3	13.55	8.04	7.21H
VI	1600.0	6.0	71.4	7.9 H [a]	14.80H [a]	8.10H [a]	6.34H [a]
VII	2000.0	6.0	75.7	7.3	14.13H	7.99	7.31H

(Experiment, from July 15, 1939, to October 25, 1939)

Ia	0	0	115.80H	14.50H	29.99	31.55H	12.22
IIa	0	6.0	110.50	13.80	32.80	27.82	10.00
IIIa	400.0	6.0	112.00H	12.30 [a]	34.20H [a]	28.26 [a]	14.40H [a]
IVa	800.0	6.0	102.50	14.00 [a]	27.46 [a]	30.44H [a]	12.23 [a]
Va	1200.0	6.0	105.60	14.80H	34.65H	28.45H	18.25H
VIa	1600.0	6.0	111.50H	15.20H [a]	35.74H [a]	26.45 [a]	15.40H [a]
VIIa	2000.0	6.0	101.90	13.50	31.50	26.44	12.25

[a] Computed.

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COLLEGE AND ALUMNI NOTES

The following papers were read and discussed before the Los Baños Biological Club meeting on November 28, 1940:

Mr. R. T. Cortez. The impact bending properties of twelve Philippine dipterocarps.

Mr. M. V. Arnaldo. Scale of living of freshman students in the College of Agriculture.

The following papers were presented before the meeting on December 12, 1940:

Mr. M. D. Sulit. Botanical explorations of Mt. Labo, Camarines.

Dr. F. O. Santos and Mr. N. A. Pidlaoan. Studies on the food of 112 families of laborers of the Philippine Lumber Manufacturing Company, Catabañgan, Ragay, Camarines Sur.

Dr. J. M. Capinpin, of the Department of Agricultural Botany, was the guest speaker at the regular technical conference of the Bureau of Plant Industry, held at Manila on December 7, 1940. He spoke on chromosome doubling and its rôle in plant improvement.

In its meeting on December 12, the Society for the Advancement of Research elected the following senior students of the College associate members: Glicerio M. Garcia, Prayul Siddhijai, and Luciano E. Lactao; as active members: Dr. Nicolas L. Galvez, of the College, and Prof. Calixto Mabesa and Prof. Emiliano F. Roldan, of the School of Forestry.

The officers of the College student body for the second semester are: president, Pastor V. Manalo; vice-president, Hipolito Custodia; secretary, Francisco Rentutar; treasurer, Nelia Teodoro; representatives to the U. P. Student Council, Luciano Lactao and Glicerio Garcia; representative to the College orchestra, Felix Cabanos; representative to the College cooperative store, Rufino Gatchalian; and representative to the Molawin Hall, Domingo Gabertan. Dr. Valente Villegas is the adviser.

THE EXPERIMENT STATION

LIST OF AVAILABLE CIRCULARS

Circular No. 2.—Bud Rot of Coconut (Revised, June, 1934) - - - *By G. O. Ocfemia*

Circular No. 3.—Experimental Errors and Application of the Probable Error to and the Interpretation of Experimental Results - - - - - - - - - - - - - *By Nemesio B. Mendiola* (Published as Chapter IV in *A Manual of Plant Breeding for the Tropics*, 1926, also sold by THE PHILIPPINE AGRICULTURIST at ₱3.25, paper bound, and ₱5.25, cloth bound, in the Philippines, and ₱3.50 and ₱5.50 elsewhere, postpaid.)

Circular No. 5.—Poultry Raising Made Easy (Revised) - - - - *By F. M. Fronda*

Circular No. 7.—How to Produce New Varieties of Gumamela (Hibiscus) - - - - - - - - - - - - *By Nemesio B. Mendiola*

Circular No. 8.—Horse Breeding in the Philippines - - - - - *By Valente Villegas*

Circular No. 9.—Fences for Farm Animals - *By B. M. Gonzalez and J. P. Esguerra*

Circular No. 10.—Practical Directions for Coffee Planting - - - *By Pedro A. David*

Circular No. 11.—The New College Copra Drier—Prepared in *Department of Agricultural Chemistry* with cooperation of *Department of Agronomy and Extension*. (Revised by *Moises M. Kalaw*).

Circular No. 14.—Beriberi: Its Causes and Prevention - - - - - *By F. O. Santos*

Circular No. 15.—Cattle Raising under Philippine Conditions - - *By Valente Villegas*

Circular No. 16.—A Simple Farm Record for the Farmer - - *By Francisco M. Sacay*

Circular No. 17.—College Trapnest - - - - - - - - *By F. M. Fronda and P. S. Pale*

Circular No. 18.—Surveying for Area with a Surveyor's Staff - *By Alexander Gordon*

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